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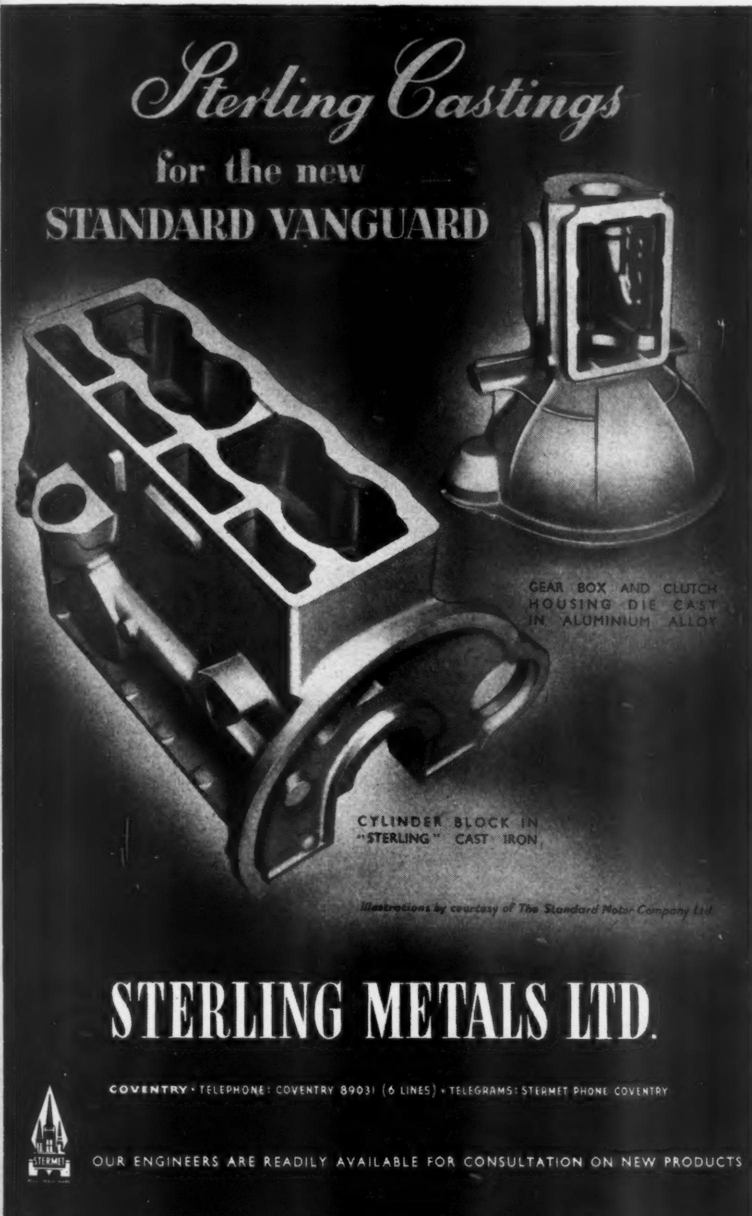

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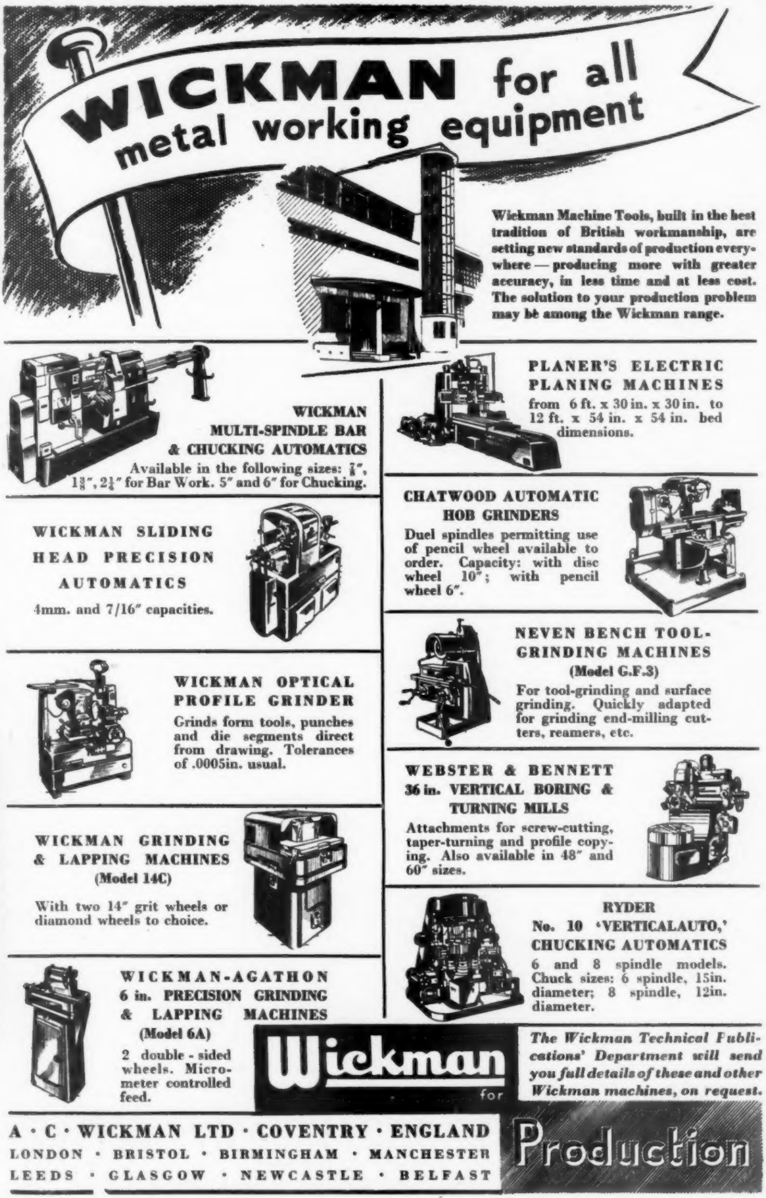
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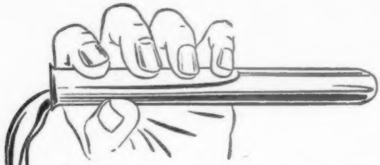

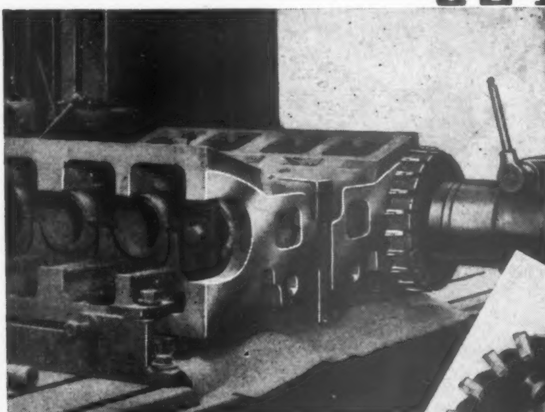


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F. P. LAURENS, O.B.E., M.I.P.E., M.I.Mech.E.

Institution Personalities — 13.

F. P. LAURENS, O.B.E., M.I.P.E., M.I.Mech.E.

F. P. LAURENS, O.B.E., M.I.P.E., M.I.Mech.E.

An outstanding figure in industry and one of the most prominent members of the Institution, Mr. F. P. Laurens is being appointed to the Board of Directors of Vickers-Armstrongs Limited. He will shortly be taking up his duties as Director-in-charge of Engineering with that Company at Barrow-in-Furness.

Mr. Laurens is a product of Vickers and served his apprenticeship, completed in 1923, at the Erith Works. His technical education was received at the Woolwich Polytechnic. He joined the staff of Vickers-Armstrongs in 1925 as a Ratefixer and subsequently passed through the various production engineering sections.

In 1931, following the closure of the Erith Works, he was transferred to Vickers-Armstrongs Limited, at Crayford, where he became Chief Ratefixer. After various important promotions, in 1938 he was made Works Manager, and while holding this position considerable expansion which was necessitated by war-time needs took place, the increased personnel finally reaching a total of 10,000.

In 1942, Mr. Laurens was transferred to the Vickers-Armstrongs war-time Manchester Works as Works Superintendent, and in 1943 he was loaned to the Admiralty as Manager of the Royal Naval Torpedo Factories and Range in Scotland, to carry out vital reorganisation and expansion of output to meet the heavy demand for torpedoes by the Royal Navy and Royal Air Force. On completion of this work he returned to the Vickers-Armstrongs organisation as Works Superintendent at Crayford.

Mr. Laurens was awarded the O.B.E. by His Majesty the King in the Birthday Honours in 1944, and later in that year was made a Special Director of Vickers-Armstrongs Limited. In addition to his duties at Crayford Works, he was also a Director of G. J. Worssam & Sons Limited, Brewery Engineers, a subsidiary company of Vickers.

In June, 1948, Mr. Laurens was asked to take over the duties of Acting General Manager of Powers-Samas Accounting Machines Limited, in which company Vickers-Armstrongs hold a strong shareholding interest, and in the following September, was appointed to the Board and became General Manager, Engineering. He leaves this position to take up his new duties at Barrow-in-Furness.

From the time he became a member of the Institution of Production Engineers, Mr. Laurens has taken a live and enthusiastic interest in the work of the Institution, and his active co-operation and assistance have been of the greatest value. For the past two years he has been President of the London Section, and has been a

member of the Technical and Publications Committee for some considerable time. He also represented the Institution on the Joint Committee with the Institution of Mechanical Engineers on the Unification of Screw Threads. He is a firm believer in properly organised apprentice training, both in the Works and in Technical Colleges, and is of the opinion that sports clubs and other Works' social activities should be strongly encouraged.

INSTITUTION NOTES

September, 1949

ANGLO-AMERICAN COUNCIL ON PRODUCTIVITY - SPECIALIST TEAM ON MECHANICAL HANDLING The Institution is represented, together with the Institution of Mechanical Engineers, the Institution of Electrical Engineers, the Engineering and Allied Employers National Federation, the T.U.C. and the principal Trade Organisations concerned with mechanical handling, on the first Specialist Team to visit the United States under the auspices of the Anglo-American Council on Productivity. Previous teams have been sent to investigate particular industries—for example, steel foundries—and have been composed exclusively of representatives of the industry concerned. The present team will investigate and report on the utilisation of Mechanical Handling appliances, with a view to assisting manufacturing industries throughout this country to improve their methods of production.

It is intended that the knowledge gained from this visit shall be made available to all manufacturing industries in the U.K., and the Institution looks forward to considerable national advantage accruing as a result of the investigations to be made by the team.

The Institution will be represented by Mr. W. J. Dimmock, A.M.I.P.E., Assistant Works Manager of Hoover Ltd., Perivale, and Mr. W. M. Hiorns, A.M.I.P.E., Chief Materials Handling Engineer, Humber Ltd., Coventry, both members of wide experience in this subject.

SCHOFIELD TRAVEL SCHOLARSHIPS The establishment of Schofield Travel Scholarships for Graduates, for which Council now invites applications, is an outstanding development in the history of the Institution.

These scholarships, to be awarded for the first time in 1950, will entitle successful graduates to six months' study visits to the United States of America, the entire time being spent in industry. The Institution will make all administrative arrangements, and will pay all travel and subsistence expenses in connection with the visits.

The scheme was originally conceived by Mr. E. W. Hancock, M.B.E., M.I.P.E., and it is largely due to his untiring efforts that this major award can be announced. The title of the scholarships pays tribute to the long and valued service of the President, Dr. Herbert Schofield, C.B.E., M.I.P.E., and the scheme provides successful graduates with an opportunity of making an outstanding contribution to their profession and to progress in their time.

Objects of the Scheme

(*a*) To provide facilities whereby young production engineers are given an opportunity of broadening their outlook and of improving their knowledge of production functions, both technical and managerial.

(*b*) To improve productivity in this country by the implementation and dissemination of such knowledge.

(*c*) To stimulate interest in production by offering these facilities to youth.

(*d*) To help to foster a better understanding of the modes of life, social conditions and in particular of the production methods employed in the industries of the United States of America or such other countries as may from time to time appear desirable.

Conditions of the 1950 Scholarships

(1) Two scholarships will be offered, covering a six month period from February to July inclusive in the United States of America. The Council reserve the right to make no award if the entries are not considered to be of sufficiently high standard.

(2) Graduates entering for the scholarships must have attained their 23rd birthday, but not have passed their 29th birthday, on the 1st January, 1950.

(3) Application forms may be obtained from the Head Office, and should be completed and returned by candidates not later than 15th October, 1949. Successful candidates will be required to devote the whole of their time in the U.S.A. to the project which they have selected. On their return they will be required to read a paper to their own Sections and to report on the project which they have studied, in any way which may be considered desirable.

Selection Procedure

Preliminary selection will be carried out by Section Committees, who will take into consideration reports from employers and educational establishments.

Candidates who satisfy the preliminary selection committees will proceed to the next stage, which involves the preparation of a paper on :—

(*a*) The project which they wish to carry out in the United States.

(*b*) The detailed background of their own knowledge and experience in the subject which they consider will enable them to make a profitable investigation of it. (Selected projects must have a direct bearing on production and in particular on that aspect of it with which the candidate is concerned at the time of entering for the award.)

After assessment of these papers certain candidates will proceed to the final stage, and will be required to attend a group interview.

It is important to note that at all stages of the above procedure the personal qualities of candidates will be given equal consideration with their academic and industrial attainments.

FORMATION OF NEW LOCAL SECTIONS The Institution is pleased to record that Council have approved the formation of three new local Sections—in Auckland (New Zealand), Bombay and Dundee.

In view of the fact that new industries have been established in the Dundee area there is every prospect of a flourishing Section being developed. The Inaugural Meeting will be held on October 4th next.

The formation of the Bombay Section—the second branch of the Institution in India—was enthusiastically received at its Inaugural Meeting on May 30th, 1949. The rapid growth of industry in this part of India has given the Institution this opportunity of extending its facilities to a wider field.

The inauguration of a Section in Auckland is of particular interest, as this is the first branch of the Institution to be formed in the Dominion of New Zealand, and some interesting reports are anticipated in the near future.

The best wishes of the Institution for a very successful future are extended to these three new Sections.

POST-GRADUATE COURSE AT BIRMINGHAM UNIVERSITY In October this year a new post-graduate course in the principles of engineering production and industrial management is starting at the University of Birmingham, under Professor T. U. Matthew, Ph.D., M.Sc., Wh.Sch., M.I.P.E. (Member of Council), Head of the Department of Engineering Production.

The course will provide advanced training and education for production engineers intending to occupy executive positions in charge of production in industry, and is open to University graduates with degrees in engineering and science subjects, and suitable industrial experience.

Production engineers who have reached a comparable level of technological knowledge and industrial experience and who hold technical college Associateships or Higher National Certificates,

and have passed the corporate membership examinations of the senior professional institutions, or have suitable equivalent qualifications, are also eligible to apply for admission.

It is anticipated that in most cases industrial firms will sponsor candidates selected from their engineering and production staffs, not only for their technical attainments but also as showing satisfactory leadership ability. To assist independent candidates to take this advanced course, however, a number of scholarships have been made available through the generosity of Sir Peter Bennett, M.P., Chairman of the Lucas Company which provided the endowment of £112,000 leading to the establishment of the Lucas Chair in the Principles of Engineering Production, and of the Department, in the University.

The course includes lectures and practical work on the economic analysis of industrial projects ; work rationalisation (methods, motion and time study) ; job analysis and evaluation and incentive applications ; the use of statistical methods and industrial measurement ; factory planning and plant layout to ensure a safe, healthy and congenial working environment ; standard costs and the development of financial controls ; industrial relations and the application of psychology in industry.

During the nine months' course of studies, each graduate will spend about one-third of his time on a specific technological or management project, arranged as far as possible to be of direct interest to his sponsoring firm as well as to the Department. At the conclusion of the course this work will be prepared in the form of a report to management of thesis standard. By this means, each graduate will be enabled to maintain close working contact with his sponsoring firm throughout his period at the University.

Further details of the course are obtainable from the Registrar, The University, Edgbaston, Birmingham, to whom applications for admission should also be sent. The inclusive fee for nine months is £70.

DIPLOMA COURSE IN PRODUCTION ENGINEERING The Kingston Technical College is offering in September, 1949, a newly developed four-year full-time Diploma Course designed to provide the necessary education and training for students who intend taking the Associate Membership Examination of the Institution of Production Engineers.

The course is of the sandwich type with provision in the first and third years for practical experience in industry. Students must be over 16 years of age and may be admitted to the first year of the course subject to certain qualifications. All enquiries concerning the course should be addressed to the College, where enrolment will take place on 15th and 16th September.

SUCCESSFUL CANDIDATES IN 1949 GRADUATESHIP EXAMINATION

J. J. Adams, Stud.I.P.E.
N. Allen.
G. B. Anderson, Stud.I.P.E.
C. M. Andrews.
J. C. Ashworth.
J. Austin.
L. Bainbridge.
J. Barr.
W. M. R. Bell.
A. K. Bhattacharya.
R. M. Biden.
F. D. H. Bollen.
E. Brown.
R. F. Brown.
R. W. Brown.
W. R. Burrows.
J. H. Chant.
C. C. Chorley.
E. D. Cock.
J. D. Collins, Stud.I.P.E.
C. J. Corkerton.
N. E. Cornish.
W. J. Costin.
J. V. Cox, Stud.I.P.E.
C. Cussans.
R. S. Cracknell.
V. G. F. Defago, Stud.I.P.E.
F. J. Dobson, Stud.I.P.E.
A. J. Dunkley.
L. F. Edmonds.
T. Edwards.
D. J. Elbourn.
G. G. Emmerson.
R. C. Farr.
G. A. Felton, Stud.I.P.E.
P. C. Felton.
A. E. L. Fenn.
F. W. Firkins.
H. F. Gadd, Stud.I.P.E.
J. M. Gardner.
A. Gilmore.
C. Gledstone
J. F. Gray.
E. J. Grossmith.
G. P. Gummer.
M. G. Guthrie.
D. J. Harris.
H. E. Hefford.
W. A. Hendrie, Stud.I.P.E.
P. Henton.
K. E. Herrington, Stud.I.P.E.
A. D. Higgs, Stud.I.P.E.
C. Hill.
W. T. Hines.
R. A. Hinkley.
D. R. C. Holmes.
W. D. C. Huskisson.
E. H. Jacobs.
E. R. Jennings.
D. F. R. Jepp.
G. N. Johnson.
R. W. Kashyap.
P. S. Kennedy.
A. Kirk.
R. E. Kurzen.
H. R. Langrishe.
J. C. Larsen.
A. Lawlor, Stud.I.P.E.
G. J. I. Leslie.
C. C. Letton.
R. E. Lister.
J. H. Littler.
H. J. Mahady.
F. Marvel, Stud.I.P.E.
T. McDermott Fox.
G. McGowan.
D. J. R. Merritt.
D. Millar, Stud.I.P.E.
H. Moore.
T. B. Murphy.
C. J. Newman.
H. Nyman.
J. B. O'Connor, Stud.I.P.E.
M. R. Ogle.
H. G. Payne, Stud.I.P.E.
J. E. Pemberton.
R. A. Powell.
J. K. Priest.
L. T. Rees.
W. L. Richardson.
R. Rimmer, Stud.I.P.E.
P. F. Rix.
D. H. Ryder.
P. Seassau.
G. Shaw, Stud.I.P.E.
R. U. Shaw.
H. Shepherd.
F. W. Smith.
G. Sowden.
P. J. Spooner.
A. F. Sugden.
S. W. Swingle, Stud.I.P.E.
G. Sri Rama Murty.
J. E. Taylor.
L. Taylor, Stud.I.P.E.
P. A. Taylor, Stud.I.P.E.
R. L. Timings.
I. A. Thomas.

K. T. Turner.
R. Wade.
N. W. Walker.
F. W. Walton.
K. F. Watson.
R. Weir.
D. F. Wertham.
E. Willcox.
N. Williams.
G. Wittenberg.
R. G. Worrall, Stud.I.P.E.
J. Wylde, Stud.I.P.E.

LORD AUSTIN PRIZE.

History of the Award

In December, 1931, the late Lord Austin, during his term of office as President, presented the sum of £100 to the Institution to provide an annual essay prize for graduates.

This prize now takes the form of a certificate, and books or instruments selected by the writer of the winning essay.

The following Graduates have been awarded the prize:—

1932	L. R. Smith	1940	G. Withington
1933	P. C. Redwood	1941-43	No awards made
1934	L. K. Hughes	1944	A. B. Dear and W. Johnson
1935	J. Silver	1945	I. McLeod
1936	R. A. P. Misra	1946	R. W. Deutsher
1937	R. A. Cox	1947	A. Short
1938	B. M. Mason	1948	A. V. Knight

Conditions of the 1949 Prize

(*a*) Graduates under the age of 28 years may compete for the prize, *providing* they have not previously entered for it.

(*b*) Essays may be written on any subject within the field of production engineering. Titles of essays must be submitted to the Head Office of the Institution for approval by not later than September 30th, 1949.

(*c*) Completed essays must be sent in to the Head Office by not later than November 30th, 1949.

Note:—The attention of Graduates is drawn to the article on 'The Planning of Technical Papers and Reports', by the Institution's Education Officer, which appeared in the August 1948 issue of the Journal. Any Graduate who wishes to obtain a further copy of this article should apply to the Head Office.

WHITWORTH SCHOLARSHIPS

Details of the Whitworth Scholarships in engineering to be offered for competition in 1950, are announced by the Ministry of Education.

Two Senior Scholarships and five Scholarships will be available for candidates of British nationality who are not more than 26 years

of age. They are required to have had practical experience in engineering before taking up an award.

Whitworth Senior Scholarships are for candidates who possess an engineering degree or a Higher National Certificate with two distinctions, or are in the last year of a course leading to one of these qualifications. The annual value of the awards is £325 and they will be tenable for two years for a course of further training in industry or for research work. Candidates are required to submit a thesis on one of a number of specified subjects.

Whitworth Scholarships are for students whose further education has been limited to evening classes. The annual value is £200, though this amount may be increased depending on the cost of the course and the means of the holder. They are tenable for three years, either in industry or at an educational establishment. They will be awarded on the results of the Whitworth Scholarships Examination to be held in April, 1950.

Further details of the awards may be obtained from Heads of Colleges of Further Education or from the Ministry of Education, Curzon Street, London, W.1. The closing date for the competition is 15th January, 1950.

TECHNICAL APPOINTMENT

The Medway Technical College, Gillingham, requires a lecturer-instructor to teach Machine Shop Technology and Practice, up to the standard of Final City and Guilds Certificate in Machine Shop Engineering, and to teach Production Engineering subjects in the Higher National Certificate Course. The salary will be to the Burnham Scale, with additions for special qualifications. Sound industrial experience is essential.

Applications by letter should be made as soon as possible to the Principal, Medway Technical College, Gillingham, giving very full details of industrial training and experience, including the names of employing firms and duration of employment. Two testimonials and two references should be included.

ANNUAL SUBSCRIPTIONS

Members are reminded that annual subscriptions for the financial year 1949-50 became due on July 1st, 1949. Payments should be made to Head Office as soon as possible.

NEWS OF MEMBERS

Mr. W. E. Arnold, A.M.I.P.E., A.M.I.E.E., M.I.I.A., who for the past four years has been General Manager of Watliff Co. Ltd., London, has been appointed Managing Director.

Mr. D. J. Billau, Grad.I.P.E., has been appointed Technical Representative to Bloxwich Lock & Stampers Co. Ltd., Bloxwich, Walsall.

Mr. J. A. Camenzind, A.M.I.P.E., is now Sales Manager to W. E. Sykes, Ltd., Staines, Middlesex.

Mr. E. M. J. Concannon, Int.A.M.I.P.E., is now Technical Consultant for Maxam Air Equipment, a branch of the Climax Rock Drill and Engineering Works, Ltd.

Mr. F. R. Hardy-Dobney, A.M.I.P.E., is now Production Engineer with Tasker's of Andover (1932) Ltd., Andover, Hants.

Mr. J. H. Faulkner, Grad.I.P.E., has taken up an appointment as Technical Officer in the Directorate of Mechanical Engineering at the War Office.

Mr. F. S. Inglis, A.M.I.P.E., has been appointed Works Manager to Thomas De La Rue & Co. Ltd. (Plastics Division), De La Rue Extrusions, Ltd., and De La Rue Floors & Furnishings, Ltd., at Tynemouth, Northumberland.

Mr. O. C. S. Kallay, Int.A.M.I.P.E., is now Methods Engineer with the Canadian General Electric Co., Peterborough, Ontario.

Mr. J. L. Meyrick, Stud.I.P.E., has been appointed Senior Estimator Draughtsman at The New Conveyor Co. Ltd., Oldbury, Worcs.

Mr. William T. Neill, M.B.E., A.M.I.P.E., A.R.Ae.S., A.M.S.L.A.E., has been appointed Assistant Production Manager at De Havilland Propellers, Ltd., Lostock, Bolton.

Mr. R. Pigdon, A.M.I.P.E., is now Works Manager of the Cundall Folding Machine Co. Ltd., Luton.

Mr. J. L. Price, A.M.I.P.E., is now the East Africa representative of Paul Brandt & Partners, Consulting Engineers, Dar-es-Salaam.

Mr. J. A. P. Ross, Grad.I.P.E., is now in charge of the Engineering Department of Watson Bros., Glasgow.

Mr. L. R. Surtees, A.M.I.P.E., is on his way to Australia to take up the appointment of Technical Director to " CC " Engineering Industries, Ltd., Sydney, New South Wales.

Mr. S. F. Taylor, A.M.I.P.E., has joined Edgar Vaughan & Co. Ltd., of Birmingham, as Technical Representative for the Midland Area.

Mr. W. Thompson, Grad.I.P.E., is now an Advisory Officer in the Production Efficiency Service of the Board of Trade, Manchester Regional Office.

Mr. J. P. Welburn, B.Sc., Grad.I.P.E., Grad.I.Mech.E., has been appointed Production Engineer to John Ingham & Sons, Ltd., of Middlestown, near Wakefield.

Mr. T. B. Worth, M.I.P.E., Education Officer to the Institution, was recently elected a full Member of the Institution of Mechanical Engineers.

VISITOR FROM ABROAD

Mr. F. A. Jenkins, A.M.I.P.E., of the Melbourne Section, has been visiting the United Kingdom. Mr. Jenkins, who is Officer-in-Charge, Naval Ordnance Inspection Branch, at the Ordnance Factory, Bendigo, Victoria, settled in Australia in 1922.

While the visit was made primarily for reasons of health and pleasure, Mr. Jenkins has also been investigating the latest methods of inspection and production rationalisation.

OBITUARY

The Institution recently learned, with deep regret, of the death of Mr. Arthur F. Shillington, M.I.P.E., M.I.Mech.E., of the Northern Ireland Section.

BOOKS RECEIVED

"Motion and Time Study", by Ralph M. Barnes (3rd Edition). Chapman & Hall, Ltd., London. Price 30/- net.

This book covers the subject of Motion and Time Study very fully, and the new chapters that have been added, together with the manner in which the book has been rearranged, will make it a most useful addition to the library of production engineers who wish to study the latest methods of scientific management now operating in the U.S.A.

The author has spent many years teaching the science of Motion and Time Study, and has recently made a personal survey of eighty factories in order to bring his book fully up to date with the latest practice. A.Y., A.M.I.P.E.

"Engineering Materials and Processes", by L. H. Hancock, A.M.I.Mech.E. Sir Isaac Pitman & Sons, Ltd., London. Price 15/- net.

"Metals and Alloys". The Louis Cassier Co. Ltd. Price 15/- net.

"Metal Working and Heat Treatment Manual" (Vol. III), by F. Johnson, D.Sc. Paul Elek Publishers, Ltd., London. Price 21/- net.

ISSUE OF JOURNAL TO NEW MEMBERS

Owing to the fact that output has to be adjusted to meet requirements, and in order to avoid carrying heavy stocks, it has been decided that the Journal will only be issued to new Members from the date they join the Institution.

IMPORTANT In order that the Journal may be despatched on time, it is essential that copy should reach the Head Office of the Institution not later than 40 days prior to the date of issue, which is the first of each month.

SECTION MEETINGS

The following meetings have been arranged to take place in September, 1949. Where full details are not given, these have not been received at the time of going to press.

September

3rd BIRMINGHAM GRADUATE SECTION. A Graduates' Conference on "Training and Leadership in Production Engineering" will be held at the Birmingham University, Bristol Road, Birmingham, from 9.15 a.m. to 5.30 p.m.

7th WOLVERHAMPTON SECTION. A lecture on "Atomic Physics" will be given at the Wolverhampton and Staffordshire Technical College Institute, Wolverhampton, at 7.00 p.m.

8th NOTTINGHAM SECTION. A visit to the Standard Motor Company Ltd., Coventry, has been arranged, commencing at 9.30 a.m.

9th WEST WALES SUB-SECTION. A lecture on "Air in Industry", by Mr. C. W. Wheal will be given at the Technical College, Swansea, at 7.30 p.m.

13th MANCHESTER GRADUATE SECTION. A lecture on "Some Recent American Hydro-Electric Schemes, with special reference to the Boulder Dam" will be given by Mr. W. A. Hatch, M.B.E., in the Reynolds Hall, College of Technology, Manchester, at 7.15 p.m. The lecture will be illustrated by sound films and slides.

15th S. WALES AND MON. SECTION. A lecture on "Starting a New Factory", by Mr. A. R. Northover, M.I.P.E., will be given at the South Wales Institute of Engineers, Park Place, Cardiff, at 6.45 p.m.

16th WOLVERHAMPTON GRADUATE SECTION. A lecture on "Graduate Status—Its Responsibilities and Implications" will be given by Mr. T. B. Worth, M.I.P.E., M.I.Mech.E., A.M.I.E.E., Education Officer to the Institution, at the Wolverhampton and Staffordshire Technical College, Wolverhampton, at 7.15 p.m.

September—cont.

16th EASTERN COUNTIES SECTION. A lecture on " Impressions of a Tour to Canada and U.S.A." will be given by Mr. H. H. Dawson, M.I.P.E., President of the Section, in the Lecture Hall, Electric House, Ipswich, at 7.30 p.m.

19th DERBY SUB-SECTION. A lecture on "Air Operated Fixtures ", by Mr. C. M. P. Willcox, will be given at the School of Art, Green Lane, Derby, at 7.00 p.m.

21st LIVERPOOL SECTION. A lecture on " Electronic Control of Machine Tools and Self-Regulating Systems " will be given by Mr. S. A. Ghalib, B.Sc., A.M.I.E.E., at Radiant House, Bold Street, Liverpool, at 7.15 p.m.

22nd NORTH EASTERN GRADUATE SECTION. A lecture on "Graduate Status—Its Responsibilities and Implications" will be given by Mr. T. B. Worth, M.I.P.E., M.I.Mech.E., A.M.I.E.E., Education Officer to the Institution, in the Neville Hall, Westgate Road, Newcastle-upon-Tyne, 1, at 7.00 p.m.

22nd LEICESTER SECTION. A lecture on " Plate Edge Preparation for Welding by Oxy-Acetylene Cutting Process " will be given by Mr. E. Ryalls, A.M.I.W., at the Leicester College of Technology, The Newarke, Leicester, at 7.00 p.m.

26th MANCHESTER SECTION. A lecture on " Education for Management " will be given by Lt.-Col. L. Urwick, O.B.E., M.C., M.A., M.I.P.E., F.I.I.A., at the College of Technology, Sackville Street, Manchester, at 7.15 p.m.

27th LUTON, BEDFORD & DISTRICT SECTION. A lecture on " Furniture Production " will be given by Mr. R. E. Harrison in the Small Assembly Room, Town Hall, Luton, at 7.00 p.m.

SECTION ACTIVITIES

BIRMINGHAM GRADUATE

The final lecture of the 1949–50 Session was given in April by Mr. J. Loxham, M.I.P.E., M.I. Mech.E., F.R.S.A., who spoke on " The Efficient Inspection of Mass-Produced Parts ", and at the end of the month a visit was made to John Garrington & Sons, Ltd., to see mass-production methods for the manufacture of stampings and forgings.

The 1949–50 syllabus will again include a film evening, and an evening set aside for dealing with members' questions on technical matters.

CORNWALL The present series of lectures was concluded on 14th April, with a paper on " Mechanical Handling Equipment ", by Mr. F. T. Dean.

This Section is somewhat isolated but the Committee is pleased to report that the lectures are attended by a gratifying number of students from the Camborne Technical College and occasionally from the School of Mines.

COVENTRY GRADUATE The Section activities this quarter have been confined to Committee Meetings for discussion of the Lecture Programme for 1949–50 Session, and there has been a good response to the circular sent to all members asking for suggestions for the Lecture Programme. By analysing the questionnaire, the Committee hopes to arrange a Lecture Programme to suit the majority of members.

DERBY SUB-SECTION The 1949–50 Lecture Programme has now been completed, and the Committee have chosen for each meeting a specific production engineering subject.

At the Annual General Meeting held in March, a sincere vote of thanks was passed to Mr. G. Harrison, M.I.P.E., who retires as Chairman after holding office for two years.

EASTERN COUNTIES A very successful Session has been concluded, and the programme for 1949–50 is almost complete. Applications for membership in this area remain at a reasonably high level.

EDINBURGH The Lecture Programme was concluded in April, when Mr. P. H. Briggs, B.Sc., gave a well-attended address on " The Use of Electronics in Industry ".

Council have agreed to the formation of a Section in Dundee, and this should give added strength to the Institution as considerable development is taking place in that area.

The Section Committee feel that the Session just ended, which was the first since the War to be completely organised, has given ground for considerable satisfaction, as the Institution is now better known in the city, and has on several occasions drawn comment from the Press.

HALIFAX At the Annual General Meeting on 14th March, Mr. H. Nutton, M.I.P.E., was elected President for the second year. The meeting was followed by Mr. Windeler's lecture on " Mechanical Mishaps and Their Relation to Design and Workmanship ".

In April, a lecture on " Product Design " was very well presented by Mr. B. G. Bowden.

In May a Section Committee Meeting was held following a tour of Hopkinsons Limited, Huddersfield, when details for the 1949–50 syllabus were completed.

LIVERPOOL The Annual General Meeting was held on 20th April and in the absence of the Section President, Mr. B. A. Williams, O.B.E., M.I.P.E., in South Africa on business, an address was given by Mr. J. France, M.I.P.E., on " This Leadership Business ".

The very excellent attendance of members at the meeting, and the general interest taken in the programme for the 1949–50 Session augurs well for the future.

LONDON At the Annual General Meeting held on 24th March, the retiring President, Mr. F. P. Laurens, O.B.E., M.I.P.E., M.I.Mech.E., thanked the members of the Committee for their enthusiasm and regular attendance, and introduced the President-Elect, Mr. W. Core, M.I.P.E., who had been a member of the Section Committee for many years and was also a member of the Technical and Publications Committee. Following the Annual General Meeting, a lecture was given by Mr. R. F. Tylecote, M.Sc., A.M.I.E.E., on " Pressure Welding ", and on 14th April, Mr. G. E. Windeler, M.I.Mech.E., M.I.Mar.E., M.Cons.E., gave an unusual lecture on " Mechanical Mishaps and Their Relation to Design and Workmanship ". The last lecture of the season was " Modern Aspects of Centreless Grinding ", by Mr. A. Scrivener, M.C., M.Inst.B.E. These lectures were well attended and extremely interesting and stimulated keen discussion.

The Institution Awards for 1949–50 were presented by Dr. H. Schofield, C.B.E., President of the Institution. Prior to the lecture meeting on the 19th May, an informal dinner party was held at which Mr. Laurens welcomed on behalf of the Section, the President, Members of Council, Section Presidents, and Mr. H. le Cheminant, M.I.P.E., a member of the Australia Sub-Council.

The Section has nominated Mr. W. J. Simons, A.M.I.P.E., to represent the Institution on the London City and Guilds Institute Advisory Committee on Welding.

The Lecture Sub-Committee is making good progress with arrangements for the 1949–50 programme.

MELBOURNE The April lecture was given by Mr. A. Gabriel Jones, B.Eng., A.M.I.P.E., A.M.I.Mech.E., on " Manufacture of High Speed Marine Gears ", and in May, Mr. R. V. Schultz, A.M.I.P.E., presented an interesting paper on " Some Aspects of Tube Bending ".

Early in May the Committee entertained to dinner Mr. Mansergh Shaw, A.M.I.P.E., on his return from a fifteen months' research tour of the United Kingdom and the Continent.

The Section now has members in New South Wales, Victoria, South Australia, Western Australia, and Queensland.

NOTTINGHAM Since the last report, the Section has held five meetings to discuss " Balancing Production and Purchasing to Schedule ", " Industrial Lighting ", and " Development and Design ".

The Annual General Meeting was held in March, when all the officers were re-elected to serve a second term. This meeting concluded with the new sound film " The Wimet Age ", which was further amplified by an address from Mr. H. Eckersley, M.I.P.E.

PRESTON The winter programme was concluded with a visit to the Courtaulds factory at Preston. It has been found very difficult since the War to arrange successful works visits, as most firms prefer these visits to be made on a working day, when it is difficult for members to attend.

SHEFFIELD The last of this Session's monthly informal discussions was held on the 25th March. These meetings have proved to be of real value and members agree that they provide an excellent opportunity for " round the table " discussion of current problems. On the 13th April, Mr. T. G. Rose, M.I.P.E., spoke on " How the Money Moves in Business ".

Attendance at all lecture meetings and at the monthly Committee Meetings has been very good and is a tribute to Mr. G. R. Pryor, M.I.P.E., Section President for the past two years, and an enthusiastic member of Council.

An endeavour is being made to form a Sub-Section in the Doncaster area, and all interested members are asked to contact the Hon. Secretary of Sheffield Section.

SOUTH AFRICA Mr. J. Ritchie, Director of South African Bureau of Standards, presented his paper on " Industrial Standardisation " at the April meeting, and an excellent film evening was held in May. In this month also a large number of members visited the Klip Power Station—the largest in the Southern Hemisphere—where a very pleasant and instructive afternoon was spent.

SYDNEY Since the last report the Section has held two very interesting meetings, the lectures being " The Manufacture of Woodworking Machinery ", by Mr. N. L. Eaton, A.M.I.P.E., and " Tungsten Carbide Cutting Tools ", when the meeting was addressed by a number of speakers.

It is the view of the Section Committee that the conditions outlined in the memorandum on Practical Training for the Production Engineer, received from the Education Committee, would not be applicable in Australia and Head Office was accordingly notified. A memorandum on this matter has now been prepared by Mr. E. C. Parkinson and Mr. S. E. Barratt, and is now being considered by the Section Committee.

The Committee is pleased to record that the terms relating to the Prize for Students generously donated by Mr. E. G. Bishop, M.I.P.E., have now been finalised.

WESTERN The Winter Session was concluded on 6th April, when Mr. G. Butler gave a very interesting paper on " Rolled Steel Sections ".

The programme for 1949–50 Session is nearing completion and some very interesting lectures are anticipated.

WEST WALES SUB-SECTION The Sub-Section's first Session was completed with a very excellent lecture by Mr. Martin L. Hughes, M.Sc., F.R.I.C., F.I.M., A.M.I.Chem.E., on " Research—with Special Reference to the Iron and Steel Industry ", followed by a film " Pattern for Progress—The Story of Ebbw Vale ", presented by Dr. P. M. Macnair.

It has been most gratifying to the Committee to note that all lectures have been reasonably well attended. The support given to the Institution in this district by industrialists generally, and also by the public, confirms the wisdom of inaugurating this Sub-Section.

WOLVERHAMPTON In April and May the Section enjoyed lectures by Mr. Lewis C. Ord on " Centralisation versus Decentralisation in Industry ", and by Mr. H. G. Ramsell, M.I.P.E., M.I.Mech.E., on " Locks ". At the Annual General Meeting in April, the President, Mr. A. J. Aiers, M.I.P.E., M.I.Mech.E., and the Vice-President, Mr. H. Tomlinson, A.M.I.P.E., were unanimously re-elected to hold office for the ensuing year. The Lecture Programme for the year 1949–50 has also been finalised.

WOLVERHAMPTON GRADUATE Two interesting lecture meetings have been held, one of which " Electro Static Spraying ", by Mr. J. Stribley aroused a great deal of interest among local firms. Three works visits have also been made, and the Annual Dance was a great success, both socially and financially.

A full Section programme is already arranged for the next six months.

YORKSHIRE The Session was concluded on 4th April, when Mr. Lewis C. Ord gave a talk on " Industrial Politics ", which was extremely interesting, and thoroughly enjoyed by the members.

YORKSHIRE GRADUATE In March, Dr. R. Goodacre, B.Sc., Ph.D., gave a paper on " Wire in its application to Industry ". This lecture was preceded by the Annual General Meeting, at which it was approved unanimously that the Standing Committee should be elected to serve for the 1949–50 Session.

Interesting visits have been paid to Prices Tailors Limited and the Northern Works of W. & T. Avery, Limited.

The Section Committee have also met to discuss the 1949–50 programme.

DEVELOPMENTS IN GEAR PRODUCTION

by H. PEARSON. *

Presented to the Coventry Section of the Institution, March 11th, 1949

In this paper some account is given of certain investigations that have been made in connection with cutting and finishing the teeth of the gears. In particular some research work in connection with hobbing and worm grinding processes is considered and an analysis is made of the cutting conditions in the crossed axis shaving process.

INVESTIGATIONS INTO HOBBING

Some years ago it was decided to investigate the effect of making changes in variable quantities in the hobbing of gears. In order to obtain closer control over the variables and also to minimise the cost of the test, it was decided at an early stage not to use a complete hob but to employ a single-point cutter (Fig. 1) profiled similarly to a hob tooth in order to mill material from a bar of steel of average toughness.

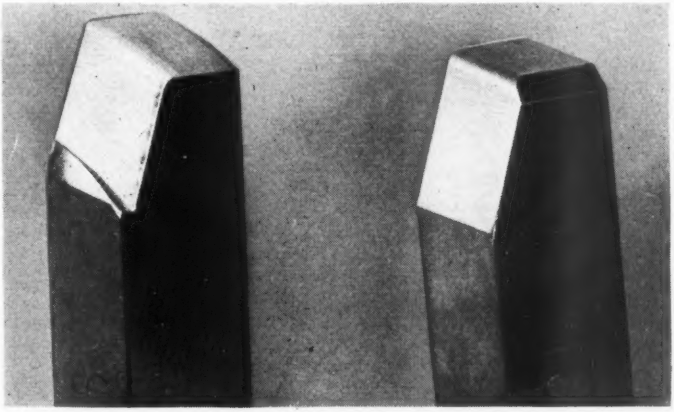


FIG. 1. Fly cutters profiled similarly to hob teeth. (Rear view.)

In preliminary tests the flat-sided form of cutter shown on the right in Fig. 1 was used but difficulties were experienced in re-setting the cutter in its holder to maintain constant effective relief angles after sharpening operations. The alternative and more costly type

* *Senior Research Investigator, David Brown & Sons, (Huddersfield) Ltd.*

of cutter shown on the left of the same illustration was therefore adopted as standard. The active end of this cutter was formed in a Hob Relief-grinding Machine to give relief angles similar to those on hob teeth. Zero rake was provided on the top face of the cutter and this was maintained in sharpening by ensuring that the sharpened face was in the plane that contained the axis of rotation of the cutter.

The condition simulated was that of finish cutting and the quantity determined was the rate of wear of the inclined cutting edge. In hobbing the most rapidly worn point is nearly always found to be on the curved part of the profile uniting the two straight parts, but in these tests the rate of wear of the inclined edge was taken as the criterion of failure.

A special cutter holder was made to suit a standard horizontal milling machine (Fig. 1A) and a special gauge (Fig. 1B) was made for the purpose of measuring the wear of the cutting edge.

The variables to be investigated include the following :

(1) Material to be cut.
(2) Material of cutter.
(3) Relief angles of cutter.
(4) Top rake of cutter.
(5) Surface finish of relieved surfaces of cutter.
(6) Surface finish of active surface of cutter.
(7) Cutting speed.
(8) Rate of feed.
(9) Thickness of cut.
(10) Nature of coolant.

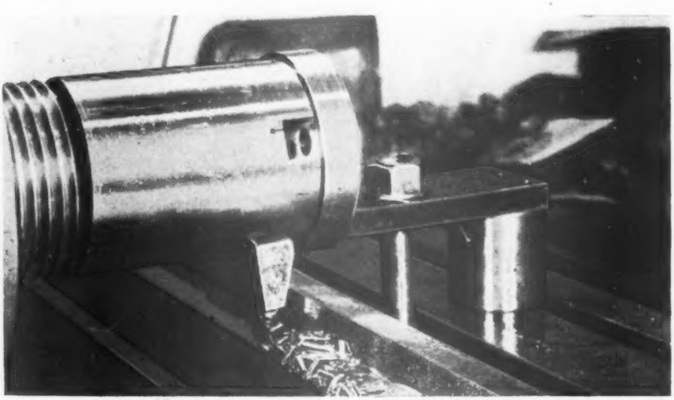


FIG. 1A. Fly cutters at work.

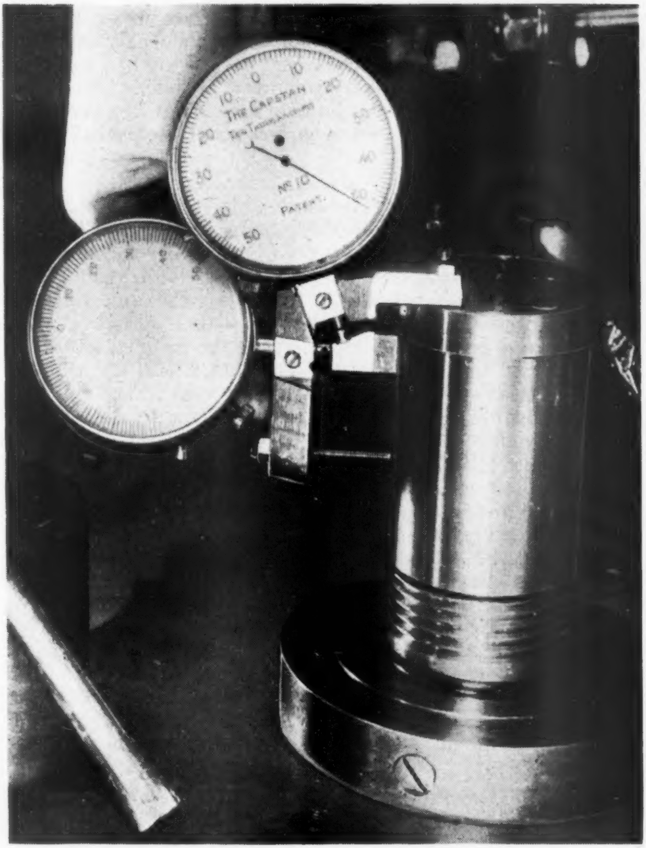


FIG. 1b. Fly cutter - wear measurement.

All the combinations of reasonable changes in these variables amount to a very large number and even with two machines running night and day there still remains much work to be done.

MATERIAL TO BE CUT

It was decided to use 0.5 carbon steel (En.9) as the standard work material for cutting tests normalised to give a tensile strength of about 47 tons per sq. in. This material is relatively inexpensive and not specially difficult

to obtain, and in the condition specified it has rather more than average toughness, although it is not exceptionally difficult to cut.

The material was first of all obtained in the form of a 4 in. square billet, but as this section was not always available, certain tests were made on 5 in. diameter circular bar milled as a preliminary operation in order to provide a surface to fit on the table of the milling machine.

MEASUREMENT OF WEAR

The wear measuring device makes three-point contact with the cylindrical surface of the cutter holder, and its endwise location is controlled by fixed dowels that rest against the end of the holder. In measuring the cutters the instrument is moved radially in relation to the axis of the cutter holder, so that the plungers of the dial indicators pass over the cutting edges of the tool. When the inclined edge only is active, the dial indicator that makes contact with the tip of the cutter reveals any radial movement of the cutter that may occur whilst the tests are in progress. The dial indicators are graduated in ten-thousandths of an inch.

Whilst some training is needed in the first instance to repeat readings with it to a sufficiently high degree of accuracy, this difficulty soon disappears and highly satisfactory results are obtained from semi-skilled labour.

The gauge is set to zero when the cutter is new and a reading is taken with the same setting of the instrument after a given length of traverse of the workpiece past the rotating cutter.

The readings are plotted graphically and a typical result is shown in Fig. 2. The records shown in the graph were compiled following tests made to determine the merits of climb cutting and in this particular instance climb cutting was shown to have an advantage in respect of resistance to cutter wear of rather more than 2 to 1 over the conventional method of cutting. Although subsequent tests have shown this ratio of superiority to be rather optimistic it is generally found that some advantage can be achieved with climb cutting, particularly when dealing with workpieces in high tensile steel.

The smooth nature of the graph is a convincing demonstration that the methods of measurement are sound.

For the main series of tests, certain quantities were given fixed values, thus :

(1) Material	0·55% carbon steel (En.9).
(5) Surface finish of relieved surfaces of cutter ...	40/50 micro in. H_{max}.
(6) Surface finish of active surfaces of cutter ...	40/50 micro in. H_{max}.

(8) Rate of feed ... ... 0·03 in. per revolution of cutter.

(9) Thickness of cut ... 0·01 in.

(10) Length of active cutting edge ... ... 0·3 in.

Conditions 1, 8 and 9 correspond to a finishing cut on a large high precision gear.

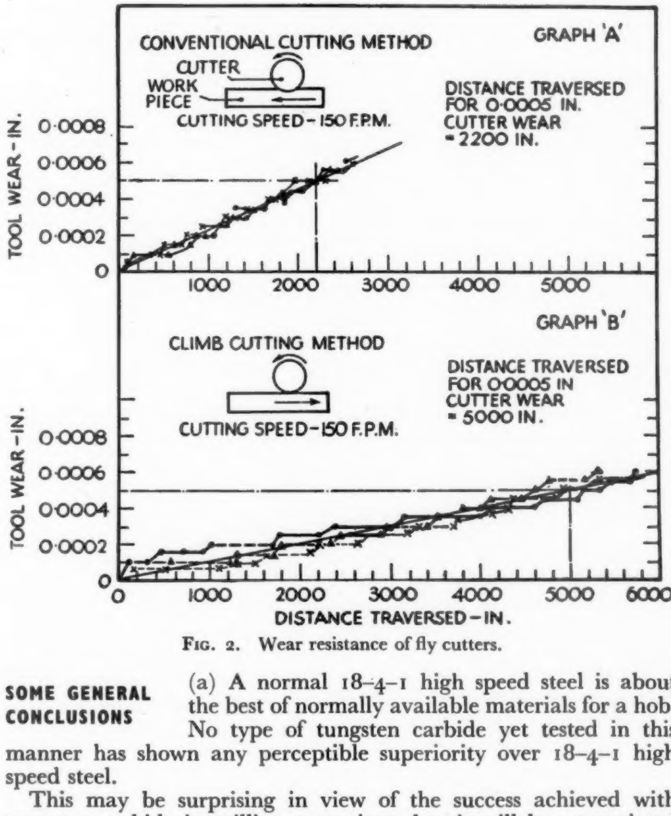


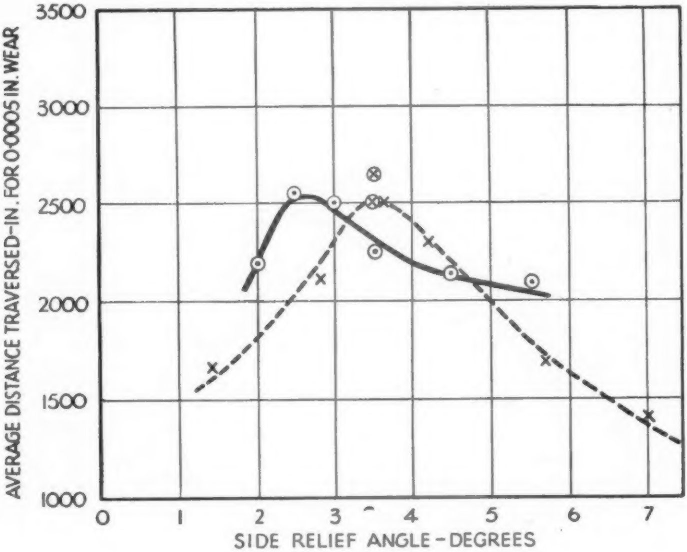
FIG. 2. Wear resistance of fly cutters.

SOME GENERAL CONCLUSIONS

(a) A normal 18–4–1 high speed steel is about the best of normally available materials for a hob. No type of tungsten carbide yet tested in this manner has shown any perceptible superiority over 18–4–1 high speed steel.

This may be surprising in view of the success achieved with tungsten carbide in milling operations, but it will be appreciated that milling and hobbing actions are somewhat different in character. Given a concentric milling cutter, all the teeth follow the same cutting path and generally speaking the feed per tooth can be

obtained by dividing the feed per revolution of the cutter by the total number of teeth. This feature does not obtain in hobbing where, as mentioned later in this paper, the heaviest duty is done by a relatively small number of the teeth.



⊙—⊙—⊙ $14\frac{1}{2}$° Pressure Angle Cutters.

×---×---× 20° Pressure Angle Cutters (results obtained in earlier tests (977529).

⊗ ⊗ Basic Tests in Present Series (20° Press. Angle Cutters).

FIG. 2A. Effect of different side relief angles on performance of fly cutters.

(b) Results of a series of tests made to determine optimum side relief angles for hob teeth are presented graphically in Fig. 2A. It will be seen that with 20 degree pressure angle cutters in 18–4–1 high speed steel operating at normal hobbing speeds, a side relief angle of about $3\frac{1}{2}$ degrees gives about the best cutting performance ; it is associated with a $9\frac{1}{2}$ degree relief angle at the tip or front face of the cutter, the relation between the two angles being determined by the normal pressure angle. This shows that the relief angles normally used today are about the best possible for general hobbing work.

(c) Superhardening of the cutters is usually found to be advantageous, particularly when the workpiece is of a high tensile nature.

(d) The life of the cutter as measured by the length of material cut before the tool wear became 0·0005 in. was found to be greatest for a cutting speed of about 120 f.p.m. This is much higher than is normally used when finishing large high precision gears.

(e) As a coolant, a general purpose lubricating oil was found to result in longer tool life than did any proprietary brand of straight cutting oil, and did not result in an inferior finish.

WEAR OF HOB TEETH

Examination of the rubbed areas of the teeth of a hob that has been used for cutting the spur or helical gears shows that the teeth in less than a single convolution are more heavily worn than any others. Very often just two or three teeth have suffered the most severely, the rubbed areas extending backwards from the rounded parts of the tip of the tooth. On such teeth the wear is approximately symmetrical, whereas that is not the case on the majority of the visibly worn teeth (see Fig. 3).

In re-sharpening the hob it is of course necessary to grind sufficient metal from the tooth faces to eliminate rubbed areas from all the teeth, and, therefore, the condition of the most heavily worn tooth decides how much metal must be removed in sharpening, and ultimately, the total life of the hob.

It is the hob tooth penetrating most deeply into the blank that suffers the most wear, and in a single-thread hob there is only one such tooth. In a multi-thread hob each thread contains a tooth that penetrates the full depth into the blank and, therefore, instead of there being just one most heavily worn tooth, there are several such teeth, one for each tnread. This suggests that multi-start hobs may have some advantage for rough cutting gears; for finish cutting to a high degree of precision they are not usually regarded with favour as they cannot be made with the same high degree of precision as is possible for a single-thread hob.

For the purpose of explanation, the foregoing remarks have been over-simplified. Taken literally they would imply that the greater the number of threads in a hob the greater the advantage for rough cutting. Actually, in a single thread hob whilst the one tooth that penetrates most deeply into the blank suffers the greatest wear, adjacent teeth before and after it on the thread suffer not much less wear, although the worst of the worn teeth cover less than one convolution, and usually about half a convolution. This suggests that there may be an advantage in using a two-thread hob as compared with a single thread hob, but that little, if any, more is to be gained by using more than two threads.

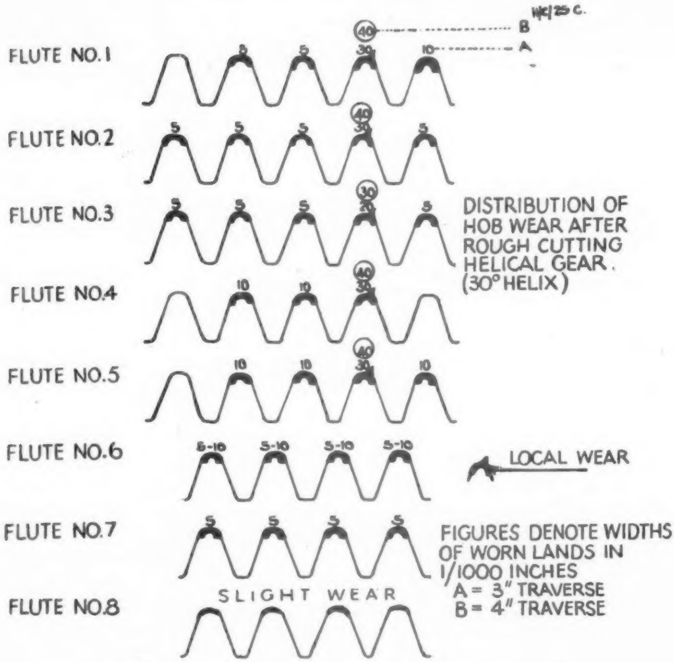


FIG. 3. Distribution of wear on hob.

In this connection it is necessary to utter a word of warning against a fallacious idea that has almost certainly influenced some users of hobbing machines. With a hob of given diameter and cutting speed, the speed of rotation of the worktable is twice as great for a two-start hob as for a single-start hob, and if the machine is set up for a given feed per revolution of the work, the cut across the width of the work will be completed twice as fast in the first case as in the second. This of course is very effective from the point of view of production, but the fact is that for a given hob life a coarser feed can be applied with a single-thread hob than for a multi-thread hob, and this leaves the advantage of the two-thread hob at less than two to one.

This is a point that requires very careful investigation, and up to the present no precise conclusion has been reached. The practice in this respect, like so many other aspects in engineering, is apt to

depend on personal preference, and so far as can be seen at present, a good deal of work is necessary before any rigorous conclusions can be reached.

CROSSED AXIS SHAVING

The crossed axis shaving process has been applied to automobile gears for a considerable time now, and extension of the process to much larger gears has directed attention to its fundamental nature.

Fig. 4 shows a spur type shaver set in engagement with a turbine pinion whose helix angle is about 30 degrees. The crossed axis angle is the difference between the axis angle of the cutter and that of the pinion.

The pinion is mounted between centres and is driven from the power head of the machine. Pressure between the shaver tooth and the work tooth is obtained by applying " brake " torque to the shaver spindle and this is effected by means of adjustable brake bands located on drums that are bolted to the shaver. Except where " patch " or selective shaving is undertaken, constant load is maintained whilst the shaver is traversed across the face of the gear.

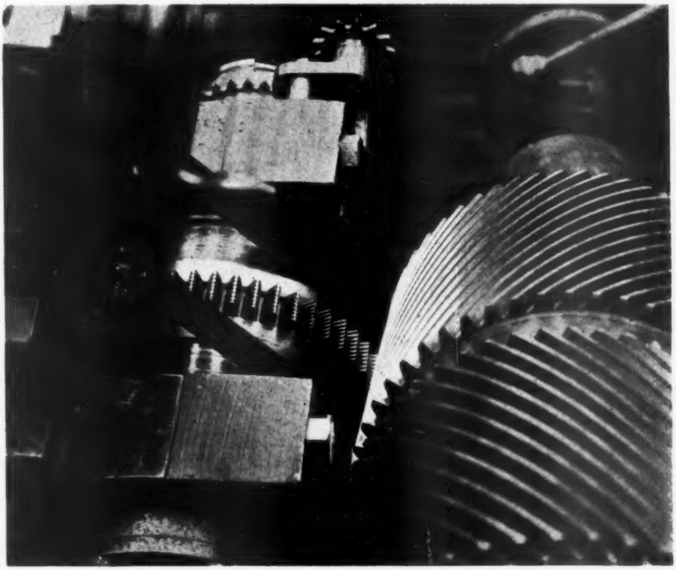


FIG. 4. Shaver in mesh with work.

Contact between two teeth of a pair of helical gears meshed on non-parallel axes is confined to a single point if the surfaces are geometrically accurate and are not deformed by loading. Elastic compression of the surfaces under load causes the contact to be spread over an area of elliptical form, with the major axis much greater than the minor axis.

The reason for this can be seen by considering Fig. 5 which represents the surface of a tooth on an involute rack. The line of contact of the flank of the tooth with a tooth of a mating helical gear placed above the rack and situated with its axis inclined to the length of the rack teeth is a straight line AB. The inclination of AB to the root line CD of the rack is about one-third of the angle between the axis of the mating gear and the direction of the rack teeth.

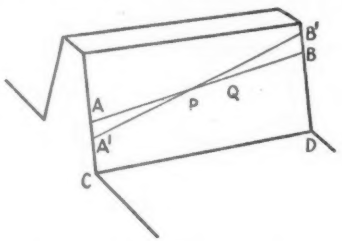


FIG. 5. Shaver - lines of contact.

A gear placed beneath the rack with one tooth touching the underside of the flank shown, and with axis inclined to the direction of rack teeth at an angle different from that of the upper gear, would have a line of contact such as for example A^1B^1 with the flank of the rack tooth. If the latter were removed, the gear teeth themselves would touch at the point P, which is the point of intersection of AB and A^1B^1 and apart from any deformation of the surfaces, contact between the teeth would be limited to that point.

It is not difficult to calculate the approximate distance of a point Q on AB from the nearest point on the profile of the tooth that contains A^1B^1, and it is thus possible to calculate the dimensions of a " zone of proximity " within which no point on either tooth is distant more than say 0·0001 in. from the nearest point of the other tooth. This zone approximates closely to the contact area over which the applied load is sufficient to produce a total compression of 0·0001 in. at the mid-point.

It is found that if gears of normal dimensions are meshed at an axis angle of about 15 degrees, small flattening of the surfaces extends the contact into a band of appreciable length. Fig. 6 gives the dimensions of the contact areas for typical cases. The contact conditions between a gear and a crossed-axis shaving cutter meshed with it are of course exactly the same as for a pair of spiral gears, and when such gears are rotated in mesh, there is at every point of contact a relative sliding parallel to the tip of the tooth in conjunction with perpendicular sliding of an amount dependent upon the

	HELIX ANGLE OF TOOTH	HELIX ANGLE OF CUTTER	AXIS ANGLE	RELATIVE CONTACT AREA
2·5	40	35	5	0·077
0·90	40	25	15	0·027
2·85	20	25	5	0·085
0·85	20	35	15	0·026

FIG. 6. Shaver - contact areas.

position of the point of contact in relation to the pitch cylinders of engagement. As the pitch cylinder of engagement usually intersects the tooth surface at or about the mid-depth of the tooth, the directions of resultant relative sliding vary from tip to root approximately in the manner indicated in Fig. 7, and this is confirmed by close examination of the surface of a shaved tooth which shows fine scratches disposed generally in the form shown in Fig. 8.

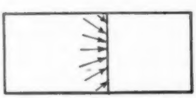


FIG. 7.

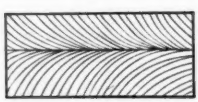


FIG. 8.

Fig. 9 represents the section of the tooth of a shaving cutter and the mating tooth of the work on a plane lying perpendicular to the common tangent plane of the tooth surfaces at the point of contact, and bisecting the zone of contact. Sliding of the cutter tooth over the work tooth in the direction indicated by the arrow is expected to cause the edges ABCD to scrape metal from the tooth of the work. It will be seen, however, that conditions are anything but favourable to cutting. The cutting edges have zero relief angle, and each of them is preceded by another tooth of zero relief that tends to prevent penetration of the edge into the material of the work.

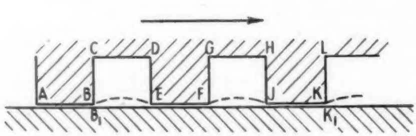


FIG. 9. Cutting action of shaver.

If the form of the work tooth is geometrically correct, very considerable pressure will permit the cutting edges to scrape extremely thin shavings of metal from the work tooth, and the pressure on the lands behind the cutting edges will provide a burnishing action. It will be realised, however, that even in the most favourable circumstances, considerable pressure is required to produce any perceptible effect on the surface of the work tooth.

If, however, the surface of the work tooth is not geometrically correct, but has local undulations, as always happens on teeth cut by conventional processes, then the teeth of the shaving cutter will act more effectively on high spots than on low spots. Consequently the shaving operation has a natural corrective action. Irregularities in the work tooth surface are attacked fairly freely whereas those parts of the surface that happen to be smooth and accurate are hardly affected.

It is found in fact, that application of the shaving process to moderately rough gear teeth causes high spots to be shaved away comparatively easily, but that once a completely shaved surface has been attained it is difficult to remove more metal from it by shaving.

This provides justification for the practice adopted by certain automobile gear manufacturers of terminating the shaving process before the work tooth profiles have been completely cleaned up.

The setting of a shaving cutter at the appropriate angle in relation to the work is a matter of some importance. It may be done by the use of marking paint applied to the cutter, and observation of the contact area when cutter and work are rotated together. Oil resisting marking paints that adequately serve this purpose are now marketed. The object is to adjust the angular setting of the cutter till the contact areas on opposite flanks of the teeth are as nearly as possible opposite to each other.

When shaving gears with facewidths many times as great as that of the shaving cutter the angular setting is not specially critical, but when shaving narrow gears the helix angle of the shaved teeth of the work may be sligntly different from the pre-shaving helix angle if the angular setting of the cutter is not correctly adjusted. The usual practice in such cases is to measure the helix of trial shaved gears and to re-adjust the angular setting of the cutter if necessary to produce a correct result.

It will be appreciated that as the area of the contact zone is critically affected by the magnitude of the crossed axis angle, so is the rate of machinability or metal removal. Tests have shown that the tooth thickness of a fairly low tensile gear can be reduced by about 0·002 in. in one pass of the cutter under fairly moderate pressure, provided that a crossed axis angle of about 30 to 40 degrees

is used. By way of comparison about 30 passes may be needed ot remove a similar amount of metai where the crossed axis does not exceed 15 degrees.

FORM WHEEL GRINDING OF WORM THREADS

For a long time past, form grinding of worm wheel threads has been carried out on one flank only at any one time. When using the usual involute helicoid thread form, this permits the use of a flat faced grinding wheel, which is merely the easiest form to trim and the method offers great practical advantages. Any worm thread form of normal size may be ground by the same flat faced grinding wheel set at the appropriate angle in relation to the axis of the work. Where the quantities of identical worms to be handled are small this facility is of particular advantage.

Where the quantities are large, however, it becomes possible to allow more time for preliminary adjustment of the grinding wheel, and if the possibility of departing from a flat faced grinding wheel is accepted, the possibility of using a wheel that will grind both flanks at once naturally comes up for consideration.

The difficulty of trimming a grinding wheel of non-plane form so as to produce a specified shape on the work within a few ten-thousandths of an inch, is well recognised. Where the trimming diamond has to follow a curved path, its exact action can be determined only by actual trial, and re-adjustment or replacement of former plates is usually found to be necessary.

If this difficulty is accepted, there arises a further one in the case of a wheel for grinding worm threads, of determining what the section of the grinding wheel on an axial plane shall be in order to produce a worm thread of involute helicoid form.

The form of the grinding wheel can be calculated and if a trimming device of the normal pantograph type is used then the former plate should have that same shape implied in tne pantograph ratio.

In a trimming device (Fig. 10) actually applied to grinding wheels for grinding both flanks of a worm at once, a different kinematic principle was used. The diamond is carried near the end of a rod sliding through a sleeve pivoted about an axis perpendicular to that of the work, with a spring acting to press the upper end of the rod against a former plate. The trimming motion of the diamond is effected by hydraulic means.

The sliding rod actually carries the diamond projecting on each side, so that by changing its angular position and causing the upper end of the rod to be pressed against a former plate symmetrically disposed in relation to the first-mentioned one, the second diamond can trim the opposite face of the grinding wheel.

A third diamond projecting axially from the end of the rod is used to trim the tip of the grinding wheel with the rod, then con-

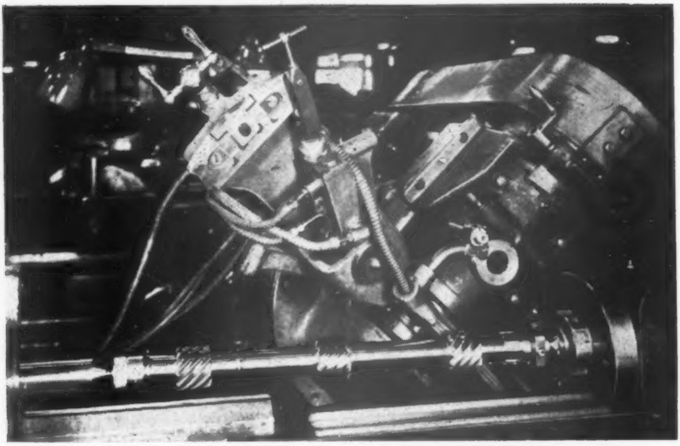


FIG. 10. Worm grinding by formed wheel method.

strained by a former plate that prevents it from sliding along the sleeve.

With this arrangement it is not to be expected that production time could be halved simply because grinding takes place on two flanks during each pass. A further advantage may be expected from the probability that the form grinding wheel makes closer contact with the worm thread.

Actually the difference between the form wheel and the flat wheel in this respect is less than might be expected, but nevertheless the form wheel does show to considerable advantage.

In one particular instance (the one illustrated in Fig. 10) which was the profile grinding of worm threads on an auxiliary shaft for the Napier Sabre engine, in conjunction with wartime needs for production, double side grinding on this particular job caused the grinding time to be reduced to about a fifth of what had previously been accepted.

As in most grinding operations the finishes obtained on the flanks of threads, ground by either single-sided or double-sided grinding wheels, are directly affected by the state of balance of the grinding spindle assembly and it has been our experience that time and trouble spent in balancing is amply repaid by the higher quality of finish achieved. Fig. 11 shows the amount of improvement gained by balancing the driving members, the spindle and the grinding wheel itself.

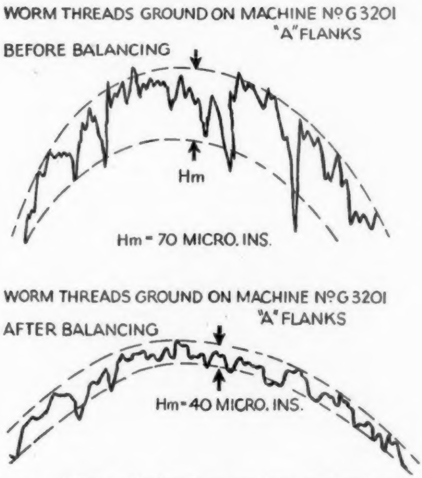


FIG. 11. Effect of balance on surface roughness of work.

The records were taken on a David Brown Topograph (Fig. 12) whose utility as a surface finish recorder has frequently been described in trade journals.

This instrument operates on a simple pneumatic principle and gives a pen record of the profile of the surface along a selected straight track. It is easily adjustable to suit any class of surface normally used in modern engineering practice.

The object to be tested is mounted on the table of the Topograph ; the tracer point is set on the surface to be tested and the instrument produces a pen on paper record 10 in. long and 5 in. wide in three minutes.

The instrument is normally used for flat surfaces, but it can also be applied to any curved surface that contains a straight line along which the tracer point may traverse.

The ratio of pen movement to tracer movement is adjustable between 5,000 and 20,000 to 1. In other words, a pen movement of 0·1 in. corresponds to roughness depth of 20 to 5 micro-inches (H_{max}) according to the setting of the instrument.

APPENDIX

Although the subject matter in this paper is mainly a record of investigations carried out in our laboratories at Huddersfield and can generally be claimed to have a practical background it may, of course, raise many controversial issues.

FIG. 12. David Brown Topograph.

We have, however, introduced into our production departments many of the developments described and consider that by so doing we have achieved improvement in economy and in the quality of the work effected by them.

PRESSURE WELDING LIGHT ALLOYS

by R. F. TYLECOTE, M.A., M.Sc., A.I.M., A.M.I.E.E.

Presented to the London Section of the Institution, March 24th, 1949

Commercial welding of non-ferrous metals, and in particular of aluminium alloys, by fusion processes involves the production of a zone of cast metal possessing strength and ductility lower than those of the wrought material.

By welding below the temperature at which the metal begins to melt, the production of a zone possessing poor mechanical properties can be avoided.

PRESSURE WELDING CONDITIONS

The means by which welding can be carried out at temperatures below the melting point is by the application to the metal of a substantial pressure, which causes sufficient movement of metal or " flow " to break up the oxide film and bring the surfaces into intimate contact. The application of this pressure causes local thinning of the material in the case of a lap joint in sheet, and an upset in the case of the pressure-butt welding of bars or tubes. The extent of this thinning or upset is a measure of the intimacy of contact at the weld face, and therefore of the strength of the weld.

In the case of light alloys, research has shown the temperature at which the welding of any given alloy is best carried out, and the

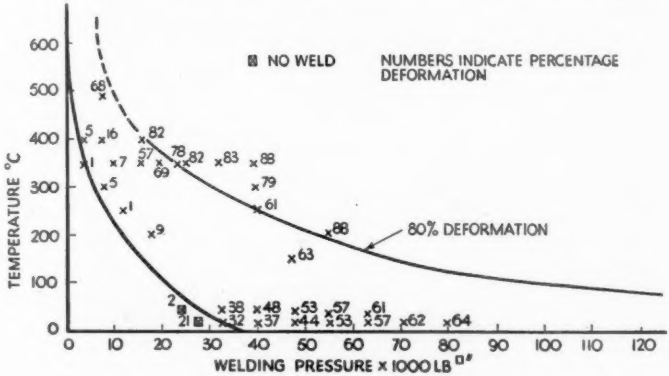


FIG. 1. Pressure welding conditions for 18 SWG high purity aluminium sheet.

amount of thinning required expressed as percentage deformation or reduction in sheet thickness. Sufficient pressure must be applied to give this degree of deformation at the welding temperature.

An example of the form in which the data is presented is shown in Fig. 1 for high purity aluminium. This shows that for successful circular welds the deformation required varies from 5–40% as the temperature of welding is reduced from 500–20°C. The pressure required to provide this deformation is less than one ton per sq. in. at 500°C. and about 15 tons per sq. in. at 20°C.

The welding conditions for aluminium clad duralumin type alloy are given in Fig. 2. Here, extremely high pressure is required to weld at low temperatures and in view of this and the large reductions in sheet thickness required, it is doubtful whether it is a practical proposition to weld this material below 400°C.

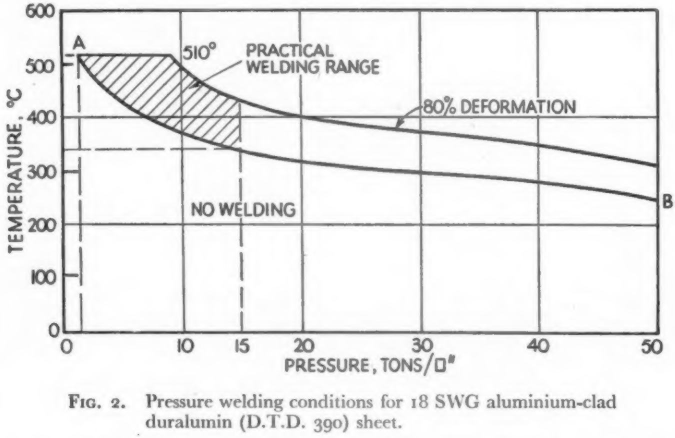


Fig. 2. Pressure welding conditions for 18 SWG aluminium-clad duralumin (D.T.D. 390) sheet.

Since this alloy is one of the heat-treatable type, it is better to weld it at a higher temperature, i.e., 490°C., and to take advantage of its age-hardening properties by rapid cooling from this temperature. Many aluminium alloys can be welded at high temperatures with deformations of the same order as that used in spot or seam welding, i.e., about 10–25%. However, as the welding temperature is lowered to room temperature, not only does the pressure required increase markedly but the deformation required increases to about 60% for commercial purity aluminium and about 80% for duralumin (see Table I).

Recent work by Sowter of G.E.C.[1] has shown that there is a field of application for pressure welding at room temperature.

The scope of pressure welding at this temperature is mainly confined to high purity and commercial purity aluminium, and some of the softer aluminium alloys, in view of the comparatively high welding pressures required.

This last requirement limits the use of the process to individual welds of small area or narrow seams. Rolls may be used and by this means long lengths of tube have been produced from strip.

In order to get the best results at low temperatures Sowter has found that metal flow can be facilitated by using narrow tools, in which the length is at least five times the width. Small welds up to ¼ in. long may be produced by a blow from a hammer on to a suitably shaped punch, and larger welds may be made in a fly press. The distortion of the component which arises from the large deformation must be allowed for in the design. Where welds are made near the edges of sheets, some dressing of the sheet edge will be necessary after welding.

STRENGTH OF PRESSURE WELDS

The strength of cold welds is usually less than that of similar shaped welds made at high temperatures, since the severe indentation of the sheet required in cold welding lowers the strength of the joint. This is to some extent offset by the local increase of strength due to cold working. Welding hard rolled sheet at high temperatures results in some softening due to annealing.

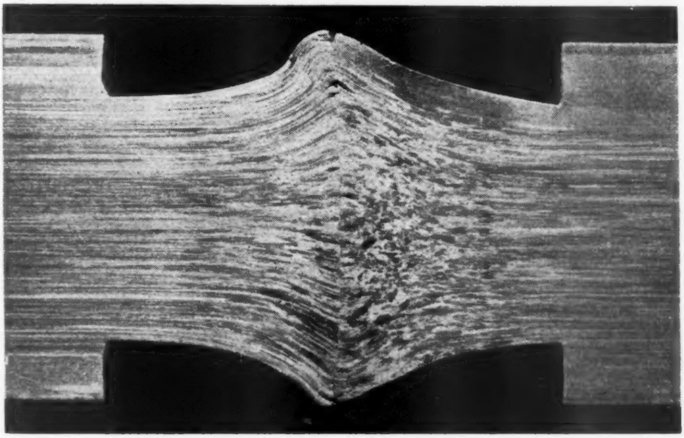


FIG. 3. Section of pressure weld in Al–Mg–Si alloy (D.T.D. 423B).

The strength of lap welds in sheet depends very much on the design of the joint, and figures for the strength of pressure welds in sheet are of academic interest only. However, tests on similar types of joint show that the strength of circular pressure welds is of the same order as that of spot welds of comparable size.[4] The strength of pressure welds in bar, on the other hand, may be compared with welds produced by other methods.[5] A typical pressure butt weld is shown in Fig. 3. The strength of such welds in aluminium-manganese and aluminium-magnesium-silicon alloys is of the same order as that obtained by the best flash-butt welding technique,[7] although the ductility of the pressure welds in the heat-treatable alloys is not as yet as good as that of welds produced by flash-butt welding. This may be due to the more rapid cooling of the flash-butt welded joints, since the latter have been made in thinner section material. Some idea of the ductility of pressure welds in ¾ in. diameter bar is shown by their behaviour during bending (see Fig. 4).

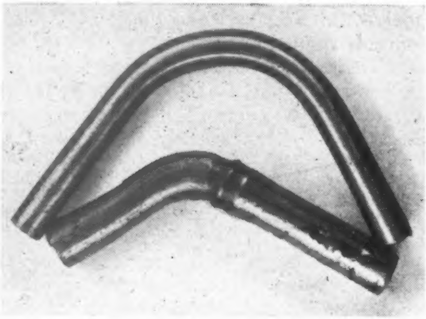


FIG. 4. Pressure weldsin ¾" diam. Al–Mn alloy bar after bending.

PRESSURE WELDING TECHNIQUE

1. *Lap welding of sheet.* The preparation of the sheet surfaces is extremely important. The material must be efficiently degreased, and then preferably pickled in one of the solutions normally recommended for use on aluminium sheet before spot welding. A typical one is a 10% solution of phosphoric acid used at 120°F. containing a small proportion of a wetting agent. This should be followed in the case of some of the aluminium alloys by a dip in cold nitric acid of about 50% concentration.

Immediately before welding the sheet should be scratch brushed, using fine steel wire brushes with a surface speed of the order of 3,000 feet per minute. If the preceding operations have been carried out efficiently, the brush will produce a fine matt surface on the sheet, but on no account must the prepared surface be touched by hand after this operation, as greasy finger marks effectively inhibit welding.

In some cases it is possible to omit pickling, but it has been found that while this step will on the whole give satisfactory results, occasional trouble can be traced to improperly cleaned sheet.

For pressure welding large components, either crank or hydraulic presses can be used. The application of pressure to the component should be so regulated as to ensure that the material is raised to the correct welding temperature before the full pressure is applied. Heating to welding temperature must be carried out under some pressure in order to prevent oxidation of the cleaned surfaces. The time required to raise the component to the welding temperature increases rapidly with material thickness. Naturally, since heat is transferred from the contacting surfaces of the dies, the time of welding depends to some extent on the ratio of weld area to total surface area of the component.

It is not possible to preheat the component in the case of light alloys due to the difficulty of preventing oxidation. If the source of heat is near to the die faces, it is possible to superheat the die while unloading and reloading so that the component parts are heated to welding temperature much more rapidly. Once the component is heated to welding temperature the time required for welding depends on the rate of application of pressure and the resultant deformation. No advantage is obtained in lengthening the welding time.

A stop or other device for preventing excessive deformation must be provided in the tools and a temperature recording apparatus is advisable.

Tools for welding at high temperatures should be made from heat-resisting steels such as the 2·0% carbon, 12% chromium type. For welding at room temperature on soft materials mild steel may be used, although unhardened chromium-manganese steel is recommended. The heating of the tools is best undertaken by means of gas, since it is difficult to insulate electric elements in tools operating at 450°C., and still obtain good heat transfer. Gas may be used by inserting burners through holes in the dies or the tools may be heated externally, in some cases with ring burners consuming oxy-acetylene. Some means of temperature control is required, and chopper-bar controllers with solenoid operated valves have been recommended.

For high temperature welding a lubricant is necessary to prevent the sticking of the sheets to the tools. One such preparation consists of 3·5 lbs. powdered talc, 175 lbs. sodium nitrate, 10 ozs. potassium nitrate, ½ oz. potassium chromate and 0·75 gallons of water. In some cases powdered talc merely dusted over the area to be welded is satisfactory.

No lubricant is necessary at room temperature or with the projection welding technique which will be described later.

2. *Butt welding of bars and sections.* The ends of the bars or sections should preferably not be sawn but machined flat. If this machining is done without lubricant no further preparation is necessary, apart from light scratch brushing before welding.

In the case of bars or tubes some chamfering is often worth while as it reduces the quantity of upset material which may have to be removed after welding. By judicious use of chamfering (see Fig. 5), dressing after welding may be entirely eliminated.

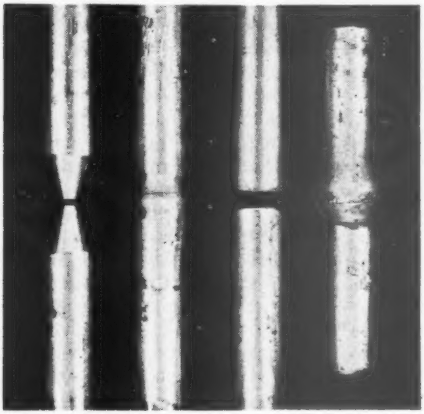


FIG. 5. Effect of chamfering on weld shape.

Heating is best carried out by means of multi-orifice oxy-acetylene burners which are usually water-cooled. These are often made in two parts so that they may readily be removed from the welded joint.

In the case of light alloys the orifices may be relatively coarsely pitched along the joint at a distance of $\frac{1}{4}$–$\frac{1}{2}$ in., compared with burners for steel in which the pitch must be a good deal closer. When oxy-acetylene is used the inner cone should not touch the surface of the metal, but terminate about $\frac{1}{4}$–$\frac{1}{8}$ in. away from it. Induction heating may be a possibility in the future, but has not been used on light alloys to the author's knowledge. The use of this method should obviate difficulties due to uneven heating in the case of solid numbers of considerable thickness.

The sections to be welded are clamped firmly in a horizontal or vertical hydraulic press and before welding a high pressure is applied so as to minimise the access of air during heating up. This should be of the order of 5 tons/sq. in. in the case of light alloys. The hydraulic pressure line is usually closed during heating-up, so that the pressure falls off as the metal gets more plastic. When the correct welding temperature is attained, the pressure in the system is suddenly increased so that the heated metal is upset and a weld obtained. Due to the plastic state of the metal at welding temperature, the upset pressure only needs to be about one-third of the initial pressure.

The relationship between pressure, temperature and time in welding by this method is shown diagrammatically in Fig. 6.

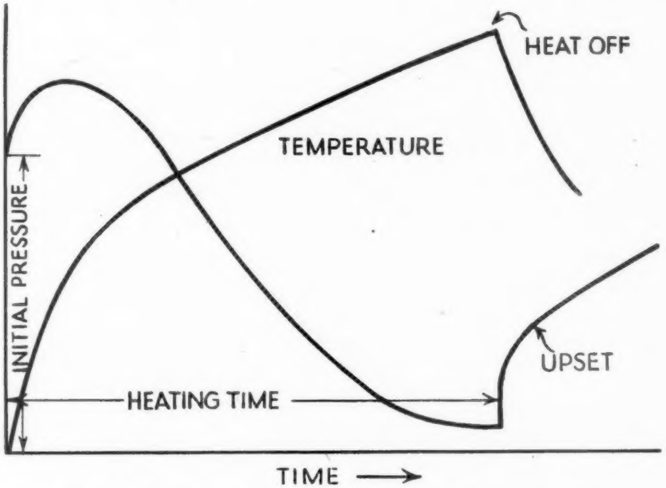


FIG. 6. Variation of temperature and hydraulic pressure with time during pressure-butt welding.

The quality of the weld is determined mostly by the degree of upset or increase of area at the weld interface. The effect of upset on the strength of welds in the Al-Mn alloy (AW3A) and in the aluminium-silicon-magnesium alloy (DTD423B) is shown in Figs. 7 and 8. Whereas in some materials, for example, commercial purity aluminium and the aluminium-manganese alloy, the actual welding temperature is not critical providing a definite minimum upset is obtained, in the case of the majority of alloys the upset must occur within a certain limited temperature range.

An indication of the welding conditions for various alloys is given in Table II, together with the joint strength expressed as a percentage of the strength of the original material.

The welding time depends to a large extent on the thickness of the members being welded. Too rapid heating means large differences in temperature between the interior and the surface, resulting in a poor weld in the interior of the joint. For example, the correct heating time for $\frac{3}{4}$ in. diameter bars is from 30 seconds to one minute, the exact time depending on the thermal conductivity of the material and the shape of the ends of the bars.

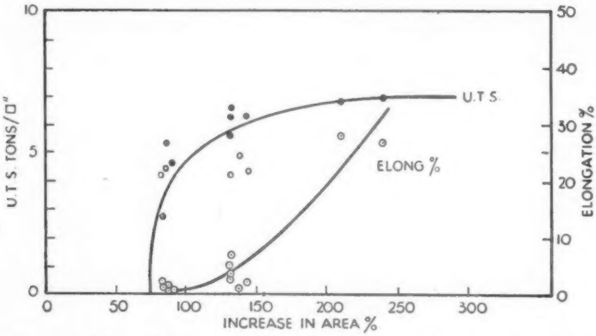


FIG. 7. Effect of upset on strength of pressure welds made at 590° C in Al-Mn alloy (AW.3).

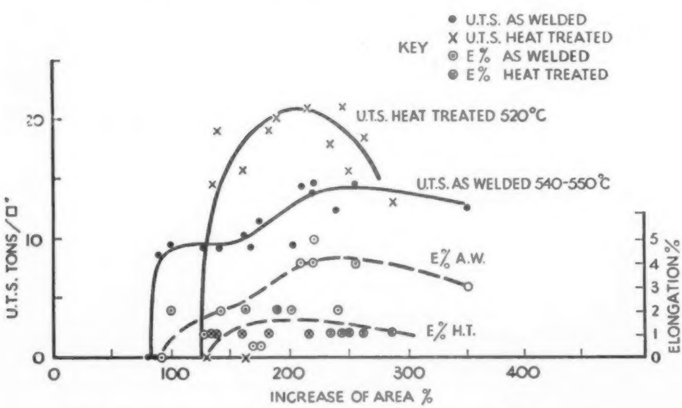


FIG. 8. Effect of upset on strength of pressure welds in Al-Mg-Si alloy (D.T.D. 423 B).

Such a time is somewhat longer than that required for flash-butt welding where the flashing time for the same cross sectional area will be about 10 seconds. On the other hand, the time required for pressure welding will be a lot less in a thinner section material, while that for flash-butt welding will remain substantially constant for the same area.

The heat input in pressure welding should be such as to raise the component to the welding temperature in a suitable time. In practice, however, it is not possible to measure the temperature at

the interface and some other means have to be used in order to upset at a certain temperature. By trial and error a satisfactory rate of heat input can be obtained by adjustment of gas flow to the burners. While it is not possible to reproduce this rate of heat input accurately in view of draughts, etc., if this method is used in conjunction with the degree of upset, good consistency can be obtained. To the production engineer other methods will occur, e.g., time of upset can be judged by noting the fall in pressure in the closed hydraulic circuit (see Fig. 6) and applying the upset pressure when the initial pressure has fallen off to a certain value. Normally the pressure rises at the beginning, due to thermal expansion of the parts being welded, then the pressure falls and upset should occur when the fluid pressure falls to a small but significant value.

APPLICATIONS (a) *German Heat Exchanger Component*. This is the first recorded application of the pressure welding process to light alloy sheet.[2] The component is shown in Figs. 9 and 10. The material used was similar to our Al-Mg-Si alloy to DTD346 or AW4, which has been found to have very good hot welding properties. The 0·016 in. thick sheets were prepared by pickling and scratch brushing. After cutting, folding and punching holes for location and the air injection nozzle, the sheets were smeared with a preparation to prevent sticking to the hot tools. The analysis was given earlier in this paper. The application of this preparation was only necessary for every second component, since sufficient of the preparation adhered to the tools.

The tools were gas heated to 450°C. and were first brought into contact with the sheet under light pressure supplied by a pneumatic

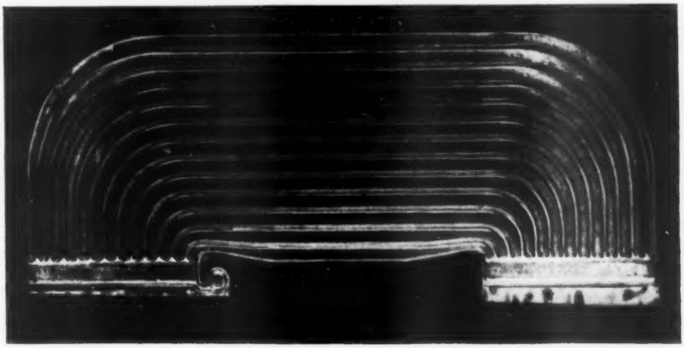


FIG. 9. Pressure welded German heat-exchanger element.

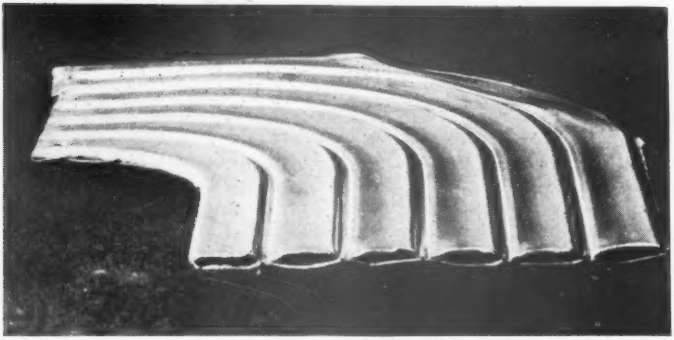


FIG. 10. Section of heat-exchanger element.

die cushion in the bed of the crank press. (The die cushion was supplied by air at a pressure of 40–50 lb./sq. in.). During the time that the press ram is descending and just before it reaches the bottom of its stroke, compressed air at 300 lb./sq. in., preheated to 450°C., is injected into the component between the sheets so as to expand the honeycomb passages against the die walls. This also controls the deformation of the sheet during welding. Immediately after this the full welding pressure is applied, amounting to 130 tons. The total time taken to make one component from floor to floor, is 30 seconds, of which 5 seconds is heating, 1 second welding time, 5 seconds for exhausting the air and 19 seconds for removing and inserting the new component. The component measured overall 20 in. × 8 in. and in this there was 40 ft. of weld seam about 0·080 in. wide. The reduction of sheet thickness at the weld area was 50–70%. The details of the tools used are shown in Fig. 11.

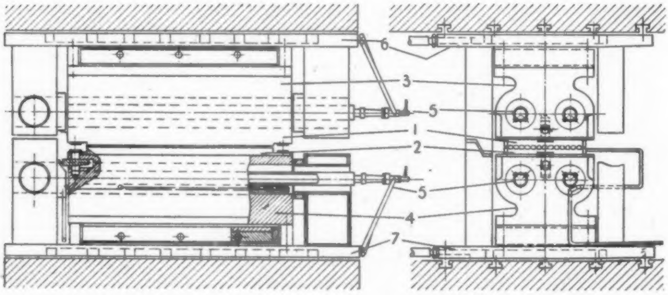


FIG. 11. Tools used for German heat-exchanger element. 1, 2: top and bottom dies; 3, 4: heat-resisting steel blocks; 5: gas burners; 6, 7: water cooled plates.

The tool material was 1·8–2·0% carbon, 12% chromium steel. The tools had produced 750,000 components before production ceased and it was thought that 1,000,000 could have been produced before redressing of the dies would have been necessary.

(b) *Pressure welding in a projection welder.* In the welding of light alloys there is still scope for a method of welding similar to the projection welding of mild steel. In the projection welding process, a high current is passed through the contact between a sheet containing a number of projections, and one without, so that a number of welds similar in shape to spot welds can be made simultaneously. It is not possible to projection weld light alloys, due to the special characteristics of these materials which allows the projection to collapse before sufficient heat is produced to make the weld. However, by means of pressure welding, several welds can be made simultaneously in a machine similar to a projection welder. The current required is much less than when spot welding light alloys and the pressure required is about three times greater. A special control gear of the "on-off" type should be fitted in order to ensure a substantially constant temperature in the weld area for a short time. One method of tooling such a job is shown in Fig. 11. High resistivity steel inserts are brazed into high conductivity blocks. The passage of current causes the high resistivity elements to heat up and heat is transferred to the sheet being welded. Due to exceedingly high pressure, resistance heating arising from the contact resistance between the sheets is almost entirely eliminated, thus avoiding inconsistency due to this source. The sheet surfaces must be cleaned as for other methods of pressure welding.

Some authorities see the eventual use of this technique in light alloy spot welding. One of the most disadvantageous aspects of spot welding compared with riveting lies in the cast material in the centre of a weld with its consequent poor ductility. Pressure welding by avoiding fusion leaves the metal in a ductile state. On the other hand, a pressure weld in lapped sheets still has one of the disadvantages of a spot weld, i.e., the notch effect between the weld and the sheets. Using tools of the type shown in Fig. 12 with 0·45 in. diameter inserts, single welds have been made in a projection welder in 18 gauge aluminium clad duralumin type alloy. The pressure used was 3,500 lbs. and the current 8,000 amps. for 100 cycles duration. The deformation was 5–10%, which compares favourably with spot welds. The resultant weld strength was about 1,000 lbs., and it is likely that had a timer of the "on-off" type been available, high strengths would have been obtained.

(c) *General applications.* The possible applications of pressure welding are numerous. The process could be used for the joining of bars, tubes, window sections, etc. In this field flash-butt welding is a competitor but pressure welding equipment has the advantage

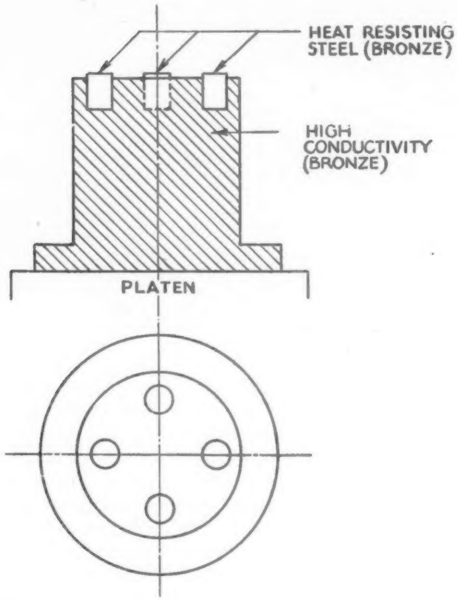


FIG. 12. Tools for making pressure welds in a projection welder.

of being more flexible and in many cases of giving better quality joints. The cold pressure welding technique developed by G.E.C. can be used for the longitudinal seam welding of tube, the welding of small articles principally involving annular seams, and the making of small welds in the assembly of toys and boxes, etc., from aluminium sheet.

In the hot welding of sheet it is possible to fabricate at one stroke of the press a complete assembly containing many tens of feet of welding. The process could be applied to car doors, metal furniture and all types of sheet metal assemblies. On a smaller scale, a modified projection welder could be used to produce a small number of individual welds in groups, such as are required for welding handles to pans, in one operation.

The application of hot pressure welding to large assemblies at the present time is a job for the development engineer. The initiative has passed out of the hands of the research worker, who has determined the welding conditions, and it is now a matter of

applying the process to a suitable assembly and tooling it up, to show that pressure welding is an economical production proposition.

The development work required to get a specific component into production will take some time as shown by the history of the German heat exchanger. Operating press tools consistently at temperatures as high as 450°C. is not a simple job, since it involves producing an even temperature over the whole die area, and eliminating warping due to temperature differences between the die faces and the attachment to the press. The advantages, however, should make the use of this process well worth while.

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4 Tylecote. *Welding Research.* 1948. Vol. 2 (5). p. 94.
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Deformations and Pressures Required for Hot and Cold Pressure Welding of Aluminium Alloy Sheet—*Table I.*

Alloy	At 490°C.		At 20°C.	
	Minimum Deformation %	Pressure tons/sq. in. of die area†	Minimum Deformation %	Pressure tons/sq. in. of die area*
High Purity Aluminium	20	1	60	10–15
Commercial Purity Aluminium ...	20	4	70	20–30
Al–2% Mg., Soft ...	20	5	70	30
Al-Mg-Si, Soft ...	10	3	71	35
Al-Mn (DTD.213A)	20	5	80	40
Duralumin-type alloy	20	5	80	> 40
Aluminium clad Duralumin ...	30	5	—	> 40

* Pressures are those required for narrow tools used in cold welding, to facilitate "flow".

† Pressures apply to circular tools. Slightly less for narrow tools.

Temperature, Upset and Weld Efficiency of Pressure Butt-Welded Joints in Bar (As Welded)—*Table* 2.

Alloy	Upset ; % increase in area	Welding Temperature °C.	% Efficiency
Al-1% Mn (AW3A)* ...	200	500–600	100
Al-Mg-Si (AW4A)* ...	250	520–560	100
Al-7% Mg (AW7A)* ...	300	500–540	80–95
Al-Mg-Si-Cu (DTD.423B)	250	500–520	65
Al-Zn-Mg-Cu (DTD.363A)	400	460–480	65
Al-Cu-Mg-Mn (B.S.6LI) ...	350	480–500	55

* B.S./S.T.A.7 Schedule.

DISCUSSION

In reply to a question as to the minimum thickness of normal commercial purity aluminium that could be pressure welded, MR. TYLECOTE said that articles had been pressure welded down to about 0·005 in.—toothpaste tubes and so on. He would say that the minimum thickness was very small indeed, of the order of 0·001 in. or 0·002 in.

Mr. HILL asked how oxidation was eliminated. Presumably raising the temperature to 450°C. would cause a certain amount. Would any flux be used ?

Mr. TYLECOTE said there would undoubtedly be oxidation if the temperature were raised in air, but he thought he had made it clear that pressure must be applied first, to seal off from the air the faces to be welded. Scratch-brushing before welding upset the surfaces and removed much of the oxide. The two pieces could then be put together and heat applied—if heat was to be used.

Mr. MAYBURY asked whether cold welding at room temperature could be applied to any other metal and whether this meant that at 200°C. one could put sheets in a punch and hit them with a hammer, which would actually weld the two together.

Mr. TYLECOTE replied that he had practised this technique at home for a long time and had made toys for his children by pressure welding. He objected to drilling a hole in a sheet and then filling it in with a rivet. It was possible to pressure weld with a hammer and punch from one side, although it was not possible to make an indentation from both sides by this means.

The G.E.C. had done a lot of work on this subject. They had applied the method to other materials, he understood, but aluminium was one of the most readily welded materials at low temperatures. They had welded copper and silver, but curiously enough although silver did not seem to have much of an oxide film, it did not lend itself readily to cold pressure welding, and required deformation of the order of 90%, so that only 10% of the original material was left. Aluminium required a deformation of about 60 or 70%, so there again only 30 or 40% remained. However, this did not detract from the value of the process. The welding could be so organised that plenty of material was left where it was wanted.

Mr. Ridpath asked whether it was a practical proposition to weld fairly small gauges of wire by the pressure welding process. He had in mind 10 gauge and smaller. Secondly, where there was this very great deformation during the weld, was it recommended that it should be annealed afterwards? He was referring now, he said, rather to cold welding where there was a material very much cold-worked and a very hard area adjacent to a comparatively soft area, which might be somewhat dangerous.

Mr. Tylecote said that as far as he was aware cold-working was usually beneficial. It increased the strength of the joint and no annealing was required. The ductility of aluminium after it had been cold-worked to approximately 100% was still extremely high, and the cold-working did not detract from it; on the other hand, it assisted in strengthening the joint. The material where locally thinned, although thinner, was stronger after cold-working and there was a safer zone on either side that had ductility.

On the question of wires, he said that the lap-welding of two wires of 10 gauge was possible. It was possible to overlap them and by using a narrow punch to weld the two together. For drawing down afterwards, however, that type of joint would be of no use. It was possible to weld small wires by the pressure butt-welding technique at higher temperatures. He himself had welded small wires of the order of 10 gauge in a lathe, putting each wire in a chuck, heating them with a blowpipe and upsetting them by moving the tailstock along.

Mr. Ogden stated that some time ago his firm had had occasion to investigate the possibilities of cold-welding aluminium foil, the gauge of the foil being something like 0·0004 in. G.E.C. carried out the investigation and found that no pre-treatment such as scratch-brushing or pickling was necessary. Obviously one could not scratch-brush foil 0·0004 in. thick. Why was no pre-treatment necessary on such a thin sheet?

Mr. Tylecote said he could not answer this question. He had always found scratch-brushing at least to be absolutely necessary,

and he was rather surprised to hear it had been found possible to weld foil without scratch-brushing or without pickling. He had himself welded materials with a form of pickling, but scratch-brushing was comparatively simple. It could be used, he thought, with a backing strip, on foil as thin as 0·0004 in.

Mr. WESTON said he had understood the lecturer to say that 490°C. was a high temperature for welding and he preferred the lower temperature of 200°C. That did not seem to be quite right, because surely it meant normalising the Alclad materials, and afterwards they could be hardened ; whereas 200°C. would soften them, and there would be difficulty in normalising and possibly also corrosion.

Mr. TYLECOTE said that this was correct. In talking about welding at 200°C. he had had in mind not Alclad, but commercial purity aluminium. By using temperatures slightly higher than room temperature it was possible to cut down the pressure immensely. One could then weld in a given press a larger area of material. If one increased the temperature from room temperature to 200°C., which should not be difficult, one could reduce pressure by about half on aluminium.

Mr. R. J. SMITH asked what were the electrical characteristics of the weld from the point of view of resistance.

Mr. TYLECOTE presumed this meant its conductivity in connection with electrical points. He said that the G.E.C., who had done much of the work on cold-welding, had found that the electrical conductivity was extremely good and perfectly satisfactory. He could not give the exact figures but in some of their literature on this subject they had said, he believed, that it was as good as an equivalent length of insulated material.

Mr. ADCOCK said he was under the impression that scratch-brushing preparation had to be carried out just prior to the pressure-welding. He foresaw difficulties there in dealing with large quantities of components in mass production. How long could the parts be left after scratch-brushing and before pressure-welding and still receive a satisfactory weld ?

Mr. TYLECOTE said there was difficulty, which could be overcome by means of an even flow of work. The maximum time interval recommended would be quarter of an hour between scratch-brushing and welding. In industrial conditions the longer the interval the more likely was the surface to be contaminated by grease-marks, etc.

Mr. ADCOCK pointed out that the rate of scratch-brushing was nothing like the rate of pressing.

Mr. TYLECOTE said that a whole line of rotary brushes on a common spindle could be used. The sheets were passed through as through a mangle and went on to the press, but with small annealed parts, difficulties might arise.

Mr. MAYBURY asked whether the speaker had had any success or any experience with castings, particularly die castings. He could visualise a manufacturer having a certain pattern cast and wanting to make modifications or additions. It might be cheaper to adopt the new principle rather than to use the old method of building up.

Mr. TYLECOTE said the grain structure did not matter. There should be no difficulty in welding die castings providing the material was cleaned up properly. He had butt-welded sand cast bars, but there was one difficulty—die castings could only be butt-welded. They could not be lap-welded.

Mr. MAYBURY said he had had experience of butt-welding nickel wire to a flat mild steel surface. The actual component was a sparking plug and there was a certain amount of undesirable deformation. After a little experimenting it was found possible to cut down the deformation by cutting down heating time. The components had been brought to the point where there was no visible deformation at the joint. There seemed to be some relationship as regards deformation between heating time and pressure. Could the lecturer explain this ?

Mr. TYLECOTE said the problem was a difficult one, two different metals being concerned. In welding them, there was fusion, giving an alloy which might be brittle. If welding time was cut down, there would possibly be less of the alloy and a stronger joint with less deformation.

Mr. REID asked whether scratch-brushing did not defeat the object of using Alclad and affect the corrosion properties.

Mr. TYLECOTE replied in the negative, adding that scratch-brushing removed a very fine surface layer, which was very thin compared with the thickness of aluminium in the thinnest Alclad sheet. The scratch-brush should consist of very fine steel wires and a very light pressure should be used. The speed should be high and just enough pressure should be applied to get a matt surface.

Mr. MASON expressed the view that pressure welding would be useful to the aircraft industry and asked what was the reaction of welds to vibration.

Mr. TYLECOTE said he could not express any opinion regarding lap-welds in sheet, since no fatigue tests had been carried out on pressure welds in sheet made with lap joints. Such welds were likely, in some cases, to be about the same as spot welds, judging by the construction of the joint, and spot welds did not compare very favourably with rivets. On pressure welds on other members, that was to say, pressure butt-welds in light alloys, there was as yet no information. A great deal of pressure butt-welding had, however, been done on steel and some of the other non-ferrous materials,

such as aluminium bronzes, and they had shown very good results in fatigue tests.

The pressure welding technique had been used in the assembly of landing gear in aircraft, presumably because it provided a very high quality welded joint.

Mr. ADAMS asked for a comparison of the cost of assembly as between fixing on the handles of saucepans by pressure welding with all the preparation necessary, and—say—piercing holes in aluminium saucepans and riveting. He felt that the preparatory work would more or less kill the pressure welding business.

Mr. TYLECOTE replied that as a research worker and not a production engineer, he was not concerned with cost. Cleaning was not very difficult, however; to put a scratch-brush across a job and put the two halves together was not very complicated or expensive as compared with drilling or piercing a hole and filling it up again.

Mr. LAURENS asked what results the lecturer had had with the pressure welding of high quality stainless steel.

Mr. TYLECOTE said he had had no experience of welding with stainless steel. He could only suppose that the temperature would be fairly high. The difficulties with pressure butt-welding of stainless steel should be no greater than with steel, which was one of the most easily butt-welded materials. Lap welding was an entirely different proposition. It was necessary to find the tools that would stand up to the pressures required at the welding temperature. Stainless steel needed quite a high pressure at not more than 700 to 800°C.

Mr. LAURENS said he had seen it done very proficiently by roll fusion in the sheet form. He wondered how it compared with pressure welding.

Mr. TYLECOTE said the pressure welding technique was used in the making of clad sheets by rolling. The three metal sheets—two of stainless steel and the centre piece of ordinary steel—were passed through the rolls together after heating. The same method was used in making Alclad aluminium. It was feasible, but making a component out of stainless steel would be rather difficult.

Mr. TOWNSEND asked whether it would be possible to pressure weld a strip of silver foil, probably about 0·004 in. thick, to the centre of a phosphor bronze strip of say 0·020 in. thick, so that the phosphor bronze strip would perhaps be about 2 in. wide and the silver some $\frac{3}{8}$ in. wide?

Mr. TYLECOTE thought this might be tried. What worried him was that the silver would be a good deal softer and would deform more than the phosphor bronze. It might be very thin, only one-tenth of what it was to begin with. If the two could be welded together, he thought the result would be electrically satisfactory.

Notes

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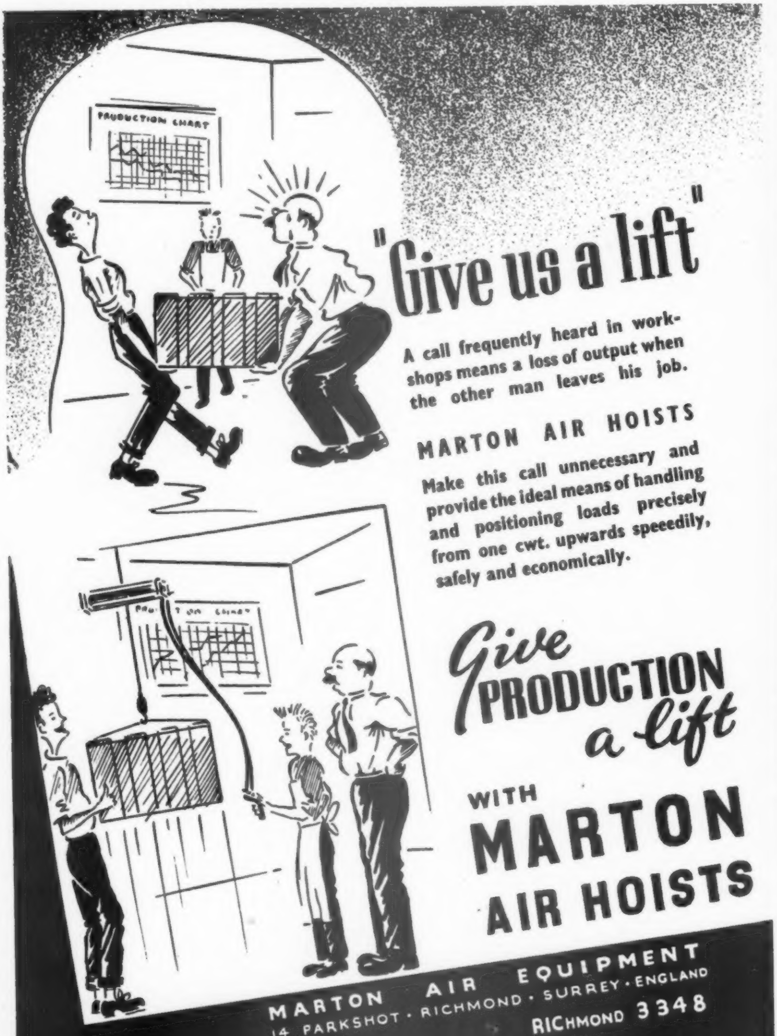

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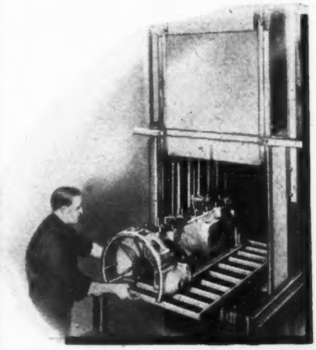

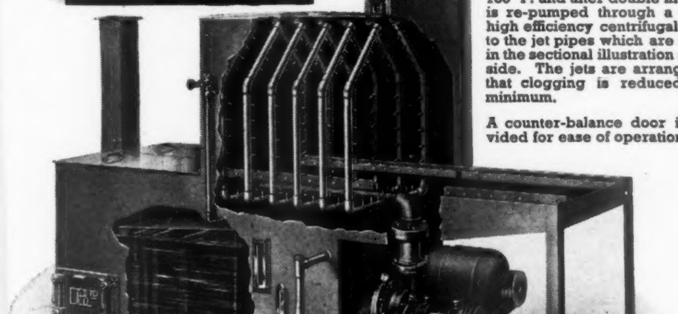

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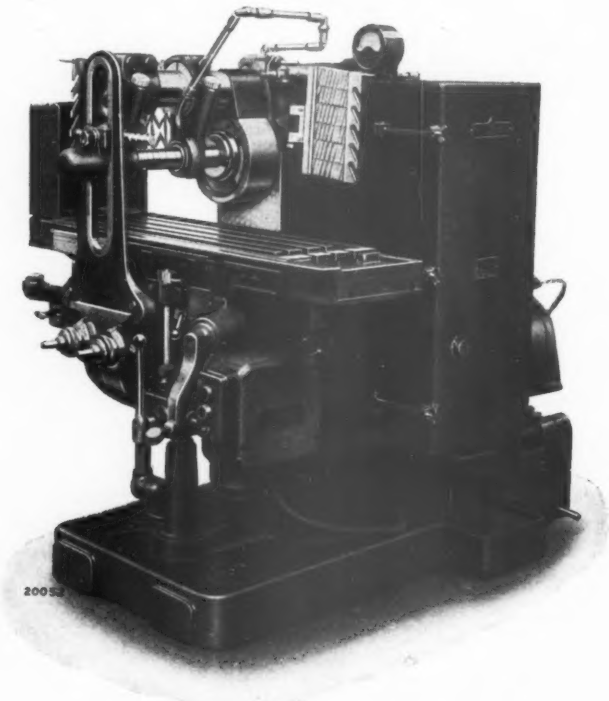

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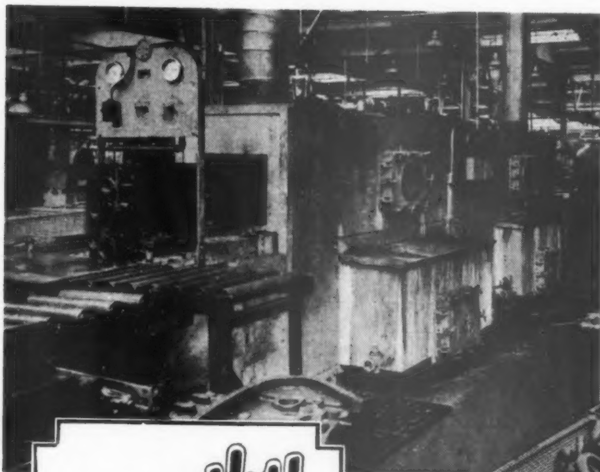

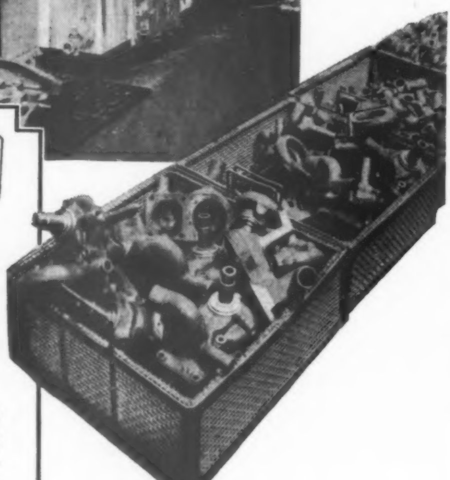

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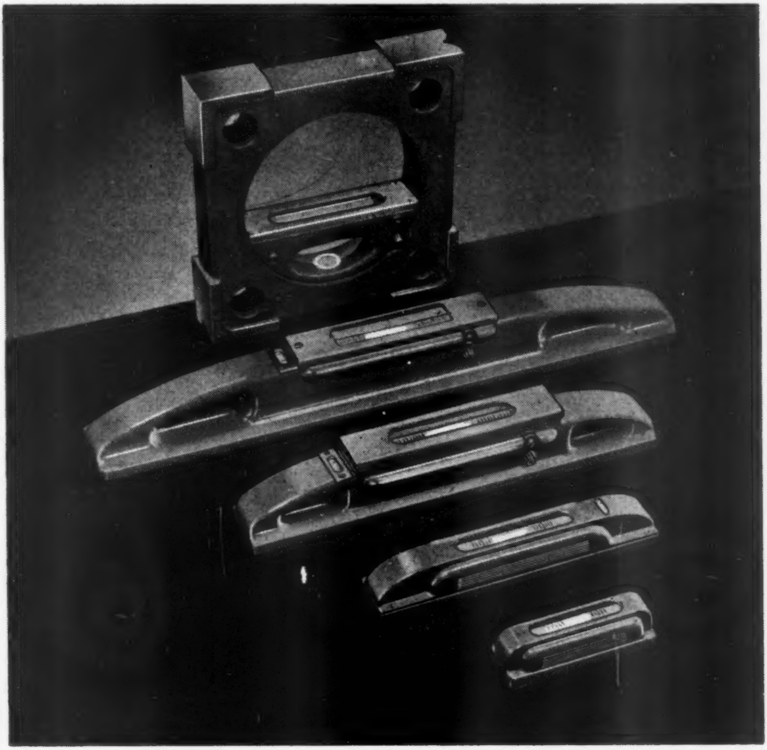

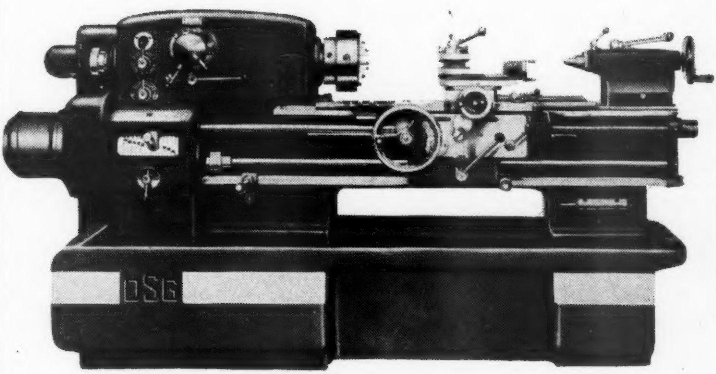

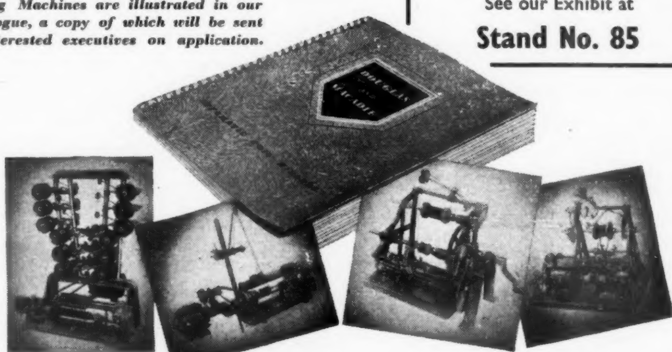

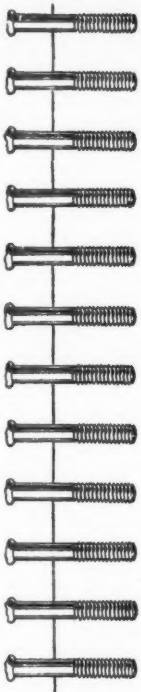

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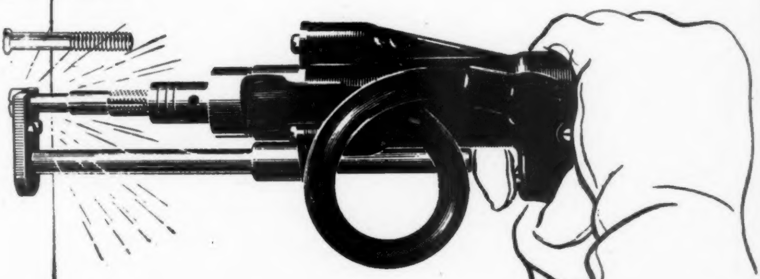

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MANUFACTURED BY
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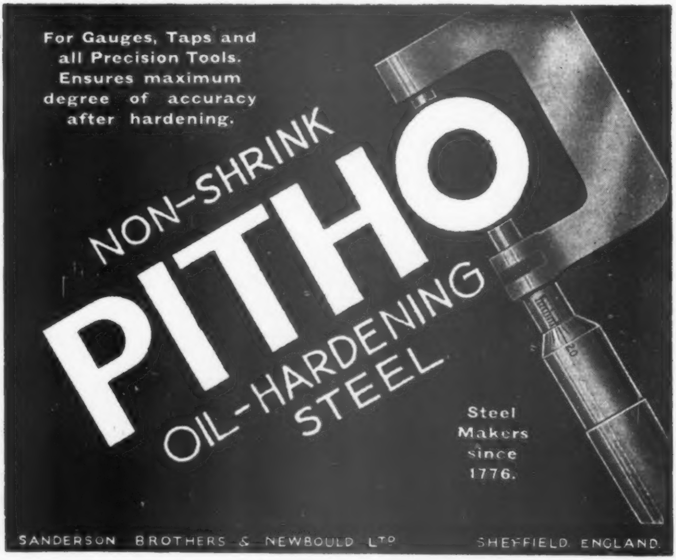
For Gauges, Taps and all Precision Tools. Ensures maximum degree of accuracy after hardening.
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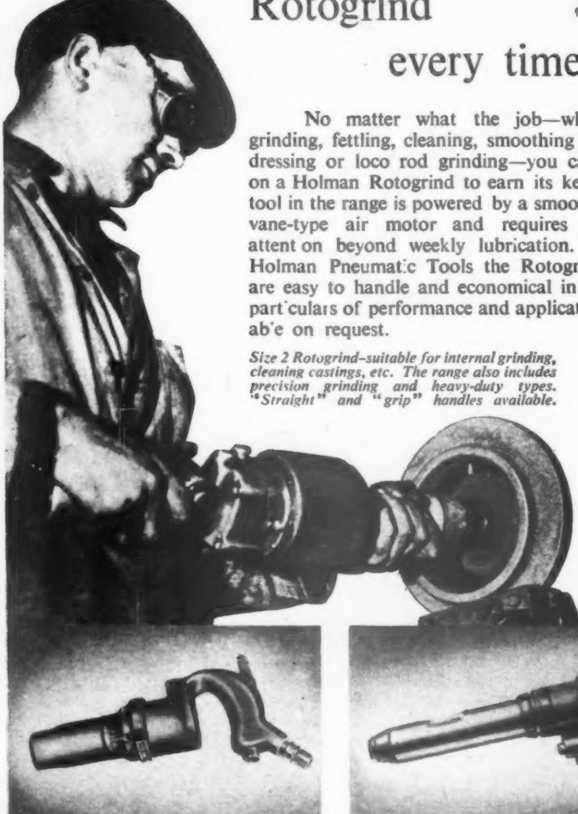
“Give me a Holman Rotogrind every time”



No matter what the job—whether it's grinding, fettling, cleaning, smoothing welds, die dressing or loco rod grinding—you can depend on a Holman Rotogrind to earn its keep. Every tool in the range is powered by a smooth-running vane-type air motor and requires very little attention beyond weekly lubrication. Like all Holman Pneumatic Tools the Rotogrind Series are easy to handle and economical in use. Full particulars of performance and applications available on request.

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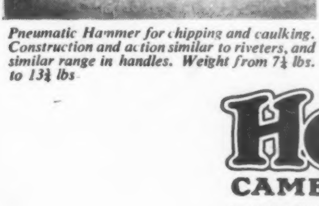

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